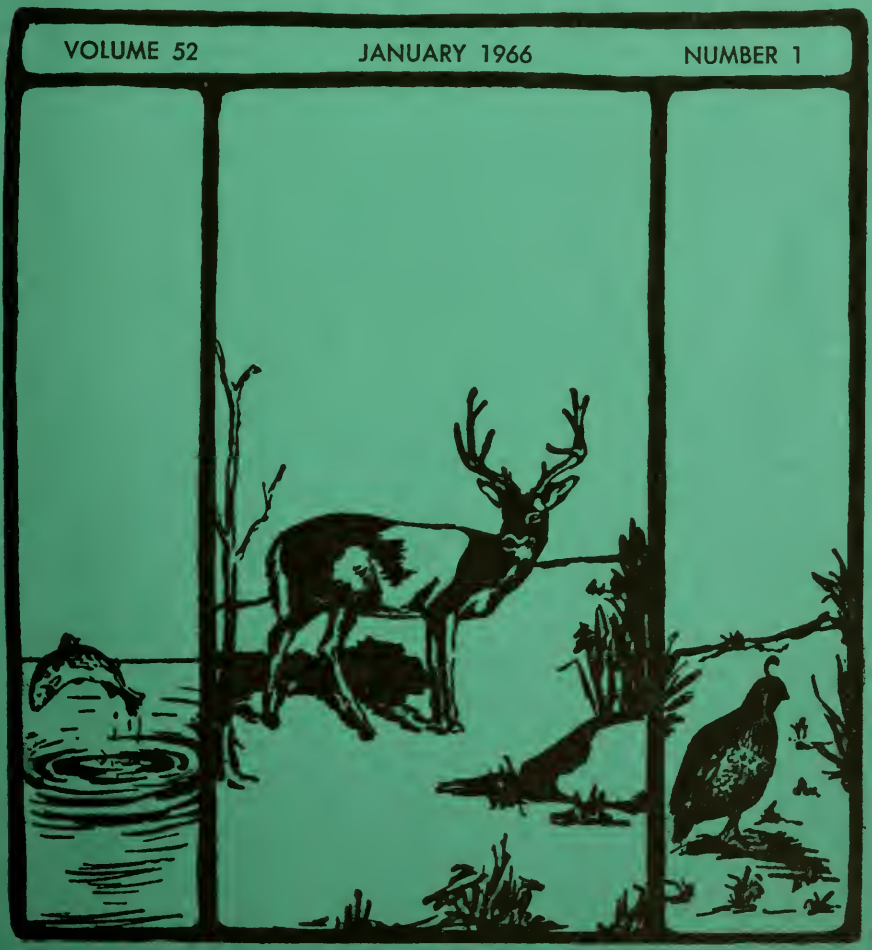
CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

VOLUME 52 JANUARY 1966 NUMBER 1



California Fish and Game is a journal devoted to the conservation of wildlife. If its contents are reproduced elsewhere, the authors and the California Department of Fish and Game would appreciate being acknowledged.

The free mailing list is limited by budgetary considerations to persons who can make professional use of the material and to libraries, scientific institutions, and conservation agencies. Individuals must state their affiliation and position when submitting their applications. Subscriptions must be renewed annually by returning the postcard enclosed with each October issue. Subscribers are asked to report changes in address without delay.

Please direct correspondence to:

JOHN E. FITCH, Editor
State Fisheries Laboratory
511 Tuna Street
Terminal Island, California 90731

Individuals and organizations who do not qualify for the free mailing list may subscribe at a rate of $2 per year or obtain individual issues for $0.75 per copy by placing their orders with the Office of Procurement, Documents Section, P.O. Box 1612, Sacramento, California, 95807. Money orders or checks should be made out to Office of Procurement, Documents Section.

CALIFORNIA FISH AND GAME

VOLUME 52 JANUARY 1966 NUMBER 1

Published Quarterly by
STATE OF CALIFORNIA
THE RESOURCES AGENCY
DEPARTMENT OF FISH AND GAME

STATE OF CALIFORNIA
EDMUND G. BROWN, *Governor*

THE RESOURCES AGENCY
HUGO FISHER, *Administrator*

FISH AND GAME COMMISSION
WILLIAM P. ELSER, *President*, San Diego
HENRY CLINESCHMIDT, *Vice President*, Redding
THOMAS H. RICHARDS, JR., *Member*, Sacramento
DANTE J. NOMELLINI, *Member*, Stockton
BRYAN E. GIBSON, *Member*, Woodland Hills

DEPARTMENT OF FISH AND GAME
WALTER T. SHANNON, *Director*
1416 9th Street
Sacramento 95814

CALIFORNIA FISH AND GAME
Editorial Staff
JOHN E. FITCH, Editor-in-Chief ..... Terminal Island
JAMES H. RYAN, Editor for Inland Fisheries ..... Sacramento
CAROL M. FERREL, Editor for Game ..... Sacramento
JOHN L. BAXTER, Editor for Marine Resources ..... Terminal Island
DONALD H. FRY, JR., Editor for Salmon and Steelhead ..... Sacramento

TABLE OF CONTENTS

Page

The Age and Growth of Centrarchid Fishes in Folsom Lake, California ... *Robert C. Tharratt* 4

Renesting of Ducks at Mountain Meadows, Lassen County, California ... *Eldridge G. Hunt and William Anderson* 17

The Marine Environment in the Vicinity of the Orange County Sanitation District's Ocean Outfall ... *Charles H. Turner, Earl E. Ebert, and Robert R. Given* 28

Length Frequencies of Pacific Hake *(Merluccius productus)* Landed in California through 1964 ... *E. A. Best and R. J. Nitsos* 49

Notes

Addition of *Tilapia mossambica* Peters to the California Fauna ... *James A. St. Amant* 54

A Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum) Recorded in Southern California ... *Jack W. Schott* 55

Northern Record of a Calico Surfperch, *Amphistichus koelzi* ... *Alex E. Peden and R. C. Best* 56

Live Coloration of a Juvenile *Uraspis secunda* (Poey) from the Eastern Tropical Pacific ... *John R. Hunter and Charles T. Mitchell* 57

Book Reviews ... 59

Calif. Fish and Game, 52(1) : 4–16. 1966.

THE AGE AND GROWTH OF CENTRARCHID FISHES IN FOLSOM LAKE, CALIFORNIA[1]

ROBERT C. THARRATT[2]
Inland Fisheries Branch
California Department of Fish and Game

The ages and growth of largemouth bass, smallmouth bass, bluegill, and red-ear sunfish in Folsom Lake, California, were calculated from scales collected during the first 7 years after impoundment (1955–1961).

All year-classes of largemouth bass grew slightly faster than smallmouth bass in the first year of life, but smallmouth bass grew faster in subsequent years. Red-ear sunfish grew faster than bluegill throughout their life.

Largemouth bass growth rates increased during the first 2 years after impoundment and declined subsequently. Smallmouth bass year-classes showed only minor differences in their growth rates. Bluegill growth rates declined markedly throughout the 7 years after impoundment. Red-ear sunfish showed a stable growth pattern for the four year-classes studied.

This report describes the growth characteristics of largemouth bass, *Micropterus salmoides*, smallmouth bass, *M. dolomieui*, bluegill, *Lepomis macrochirus*, and red-ear sunfish, *L. microlophus*, in Folsom Lake during the first 7 years after impoundment (1955–1961).

Largemouth bass growth rates have been studied at a number of California waters (Dill, 1944; Fisher, 1951; Murphy, 1951; Wohlschlag and Woodhull, 1953; Beland, 1954; Kimsey and Bell, 1955; and LaFaunce *et al.*, 1964). Bluegill growth has been investigated at Clear Lake (Murphy, 1951) and at Sutherland Reservoir (LaFaunce *et al.*, 1964), but this is the first published report on smallmouth bass and red-ear sunfish growth in California.

DESCRIPTION OF THE RESERVOIR

Folsom Lake is on the American River about 20 miles northeast of Sacramento. Completed in 1955, the reservoir is operated by the United States Bureau of Reclamation to provide water for irrigation, power, and flood protection.

This large, U-shaped lake has a gross pool capacity of 1,010,300 acre-feet and a maximum depth of 267 feet. It covers 11,450 acres with 75 miles of shoreline at full pool. Rain and snow-melt runoff from the western slope of the Sierra Nevada is stored during the winter and spring. Maximum storage occurs in June. Thereafter, gradual drawdown reduces the water level about 70 feet, and storage to about 400,000 acre-feet in December. Surface water temperatures are in the mid-40's during the winter and 75 to 80°F. in the summer. Thermal stratification occurs in the summer, but oxygen is plentiful throughout most of

[1] Submitted June 1965.
This study was performed as part of Dingell-Johnson Project California F-18-R, "Experimental Management of Warmwater Reservoirs," supported by Federal Aid to Fish Restoration funds.
[2] Now with Division of Recreation, California Department of Parks and Recreation.

the hypolimnion. The lake is classified as oligotrophic with low phosphorus and carbonate concentrations (Rawstron, 1964). The lake contains both warmwater and salmonid fishes. Smallmouth bass, largemouth bass, bluegill, green sunfish, *Lepomis cyanellus*, and white catfish, *Ictalurus catus*, dominate the catch.

METHODS

Growth characteristics were determined from scale samples which were obtained during creel censuses and various fish sampling programs in 1957 and 1960–62 (Table 1). Several scales were removed from the left side of the fish behind the pectoral fin tip. Fork lengths were meas-

TABLE 1

Folsom Lake Scale Samples Used in Age and Growth Analysis

	Collection year and number of scale samples examined				
Species	*1957* *	*1960* †	*1961* †	*1962* †	Totals
Largemouth bass	175	36	176	136	523
Smallmouth bass	158		92	212	462
Bluegill	74	93	93	129	389
Red-ear sunfish		31	103	53	187

* Samples from angler-caught fish only.
† Samples from angler-caught fish, fyke nets, seines, gill nets, electro-fishing, and rotenone.

ured in tenths of inches. Weights were measured to the nearest 0.01 pounds using a 5-pound capacity Chatillon platform scale calibrated in 0.02-pound intervals.

Scales were impressed on 1 x 3 x 0.040-inch cellulose acetate slides. Ages were determined with an Eberbach scale projector equipped with a 32-mm. Macro-Tessar lens providing a magnification of 42X.

Ages were determined by counting annuli. Measurements were made along the primary radius of the scale from the center of the focus to the scale margin. Annuli and scale margin were marked on paper strips for measurement and growth calculations.

In determining body-length/scale length relationships, scale radius measurements were grouped by 5 mm. intervals. Mean fork lengths and mean scale radii were graphed and their relationships calculated by least squares. Initially, scale measurements were plotted against the body lengths separately for each year. However, the body-scale relationships were essentially the same for all collection years, so all data for each species were combined. A direct proportion nomograph corrected for the body-length/scale-radius intercept was used for back calculation.

The length-weight data were grouped by 0.5-inch length intervals, and mean lengths and mean weights were calculated and graphed. The length-weight curves were fitted by the parabolic equation $W = CL^n$, where W = weight in hundredths of pounds, L = fork length in inches and C and n are constants.

To help validate bluegill scale readings, a comparison was made with otoliths (sagittae) under a binocular microscope by counting the number of complete translucent winter growth bands (Figure 1). A winter growth band was defined as "complete" if there was evidence of opacity (summer growth) at its margin.

Samples were not stratified by sex. Bennett (1938) found no differences in the growth rate between sexes of smallmouth bass from four Wisconsin lakes. Likewise, Beckman (1949) found no consistent differences in the growth rate between sexes of largemouth bass, smallmouth bass, and bluegill in Michigan. On the other hand, Lane (1954) and Sprugel (1954) reported sexual differences in the growth rate of bluegills.

VALIDATION OF ANNULI

The validity of annuli as year marks for centrarchids in general is well established. In this study, the good correlation between age and size of fish, the similarities between calculated growth histories of various year-classes collected in different years, and the reasonable agreement between measured lengths at capture and calculated lengths for

FIGURE 1. Bluegill otoliths (sagittae) age groups 0, I, II (winter collection); and III (summer collection). The Age II otolith was taken from the same fish as the scale shown in Figure 2. *Photograph by William E. Schafer.*

fish of the same age groups (Tables 2, 3, 6, 7) confirmed the validity of the scale annuli method for Folsom Lake.

Determining the position of the first annulus on bluegill scales presented some difficulties early in the study, because of the extended spawning season and peculiar annulus morphometry. The first annulus on many scales was indistinct with little or no "cutting over" (Figure 2), or was only a clear area between widely-spaced circuli. The validity of the annulus was established by examining scales from young fish collected during the period of annulus formation in 1962 and 1963.

The ages of 18 bluegills, ranging in fork length (FL) from 1.2 to 6.8 inches, were determined from both otoliths and scales, and agreed in all cases, further confirming the validity of scale annuli readings in bluegills.

LARGEMOUTH BASS AND SMALLMOUTH BASS

The relationship between the body length and the length of the anterior radius of the scales was determined for 585 largemouth bass from the 1957, 1960, and 1961 collections, and 256 smallmouth bass collected in 1957 and 1961. The body-length scale-length relationships for both largemouth bass and smallmouth bass were linear over the range of lengths studied. Regression lines fitted to the data were: largemouth bass, $Y = 0.89 + 0.0599X$; smallmouth bass, $Y = 1.54 + 0.0646X$.

Time of Annulus Formation

The time of annulus formation in 1961 was determined from 83 largemouth bass collected between April 27 and June 14. A new annulus was evident on less than one-third of the bass examined from the April 27 collection. By the end of May, 60 percent of the scales had a marginal annulus, and on June 14 all fish examined had resumed growth. The surface water temperatures during the period of these observations increased from 61 to 72°F.

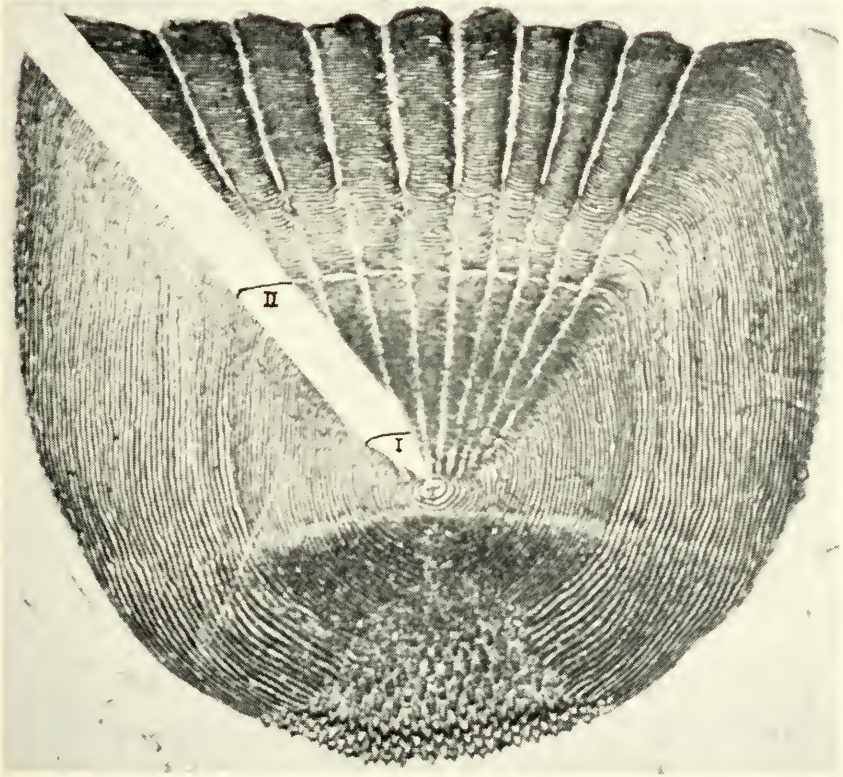


FIGURE 2. Scale impression photograph from 5.2-inch bluegill collected January 17, 1962 illustrating the difficulty of identifying the first annulus.
Photograph by William E. Schafer.

Few spring scale samples are available from smallmouth bass collected in 1961, so the time they form annuli could not be determined as well as it was for largemouth bass. However, scales from 19 of 25 smallmouth bass collected in May 1961, had a new annulus.

Growth in Length

Folsom largemouth bass grow slightly faster than smallmouth bass their first year, but this advantage is lost at the end of the second year (Tables 2 and 3). Smallmouth bass are nearly an inch longer than largemouth bass at Age III. This advantage continues through the fourth year, the last year for which comparative data are available.

TABLE 2

Calculated Fork Lengths of Folsom Lake Largemouth Bass Collected in 1957, 1960, 1961, and 1962

Age group	*Number of fish*	*Mean fork length at capture (inches)*	*Mean calculated fork length in inches at end of year of life*					
			1	*2*	*3*	*4*	*5*	*6*
I	342	7.8	5.6					
II	97	10.8	5.4	10.3				
III	55	12.8	5.8	10.3	12.6			
IV	23	14.5	6.1	10.8	13.2	14.4		
V	4	15.8	6.6	10.3	12.3	14.2	15.5	
VI	2	17.2	4.8	9.9	13.5	15.4	16.4	17.0
Mean calculated length			5.6	10.4	12.8	14.5	15.8	17.0
Mean annual increment			5.6	4.8	2.4	1.7	1.3	1.2
Number of fish			523	181	84	29	6	2

TABLE 3

Calculated Fork Lengths of Folsom Lake Smallmouth Bass Collected in 1957, 1961, and 1962

Age group	*Number of fish*	*Mean fork length at capture (inches)*	*Mean calculated fork length in inches at end of year of life*			
			1	*2*	*3*	*4*
I	191	8.2	5.2			
II	237	11.0	5.3	10.2		
III	31	13.7	5.2	10.5	13.5	
IV	3	15.5	5.2	11.2	14.1	15.3
Mean calculated length			5.2	10.3	13.6	15.3
Mean annual increment			5.2	5.1	3.3	1.7
Number of fish			462	271	34	3

TABLE 4

Growth Rates of Largemouth Bass in Various Waters in the United States [1]

Water	Source	Age group						
		I	II	III	IV	V	VI	VII
Norris Res., Tennessee[2]	Stroud (1948)	6.9	12.2	14.6	16.2	17.5	19.3	20.8
Clear Lake, California[3]	Murphy (1951)	6.7	12.2	14.8	16.7	19.8	21.4	--
Sutherland Res., California[4]	LaFaunce *et al.* (1964)	6.5	11.4	14.3	16.3	18.1		
Oklahoma Res. (State average)[2]	Jenkins and Hall (1953)	6.7	11.4	14.2	16.4	18.3	19.6	20.8
Folsom Lake, California[4]	Present study	5.6	10.4	12.8	14.5	15.8	17.0	--
Lake Havasu, California[4]	Beland (1954)	4.6	9.7	13.5	16.2	--	--	--
Colorado River, California[3]	Dill (1944)	6.6	9.6	13.0	14.8	16.2	--	--
Wisconsin Lakes (State average)[2]	Bennett (1937)	3.3	7.4	10.5	12.5	14.0	15.1	--
Big Sage Res., California[4]	Kimsey and Bell (1955)	2.3	4.6	7.2	11.5	--	--	--

[1] Ranked according to size at Age II.
[2] Average calculated total length in inches.
[3] Average fork length at capture. Murphy's and Dill's Age 1 fish are at an age between Age Group I and Age Group II, etc.
[4] Average calculated fork length.

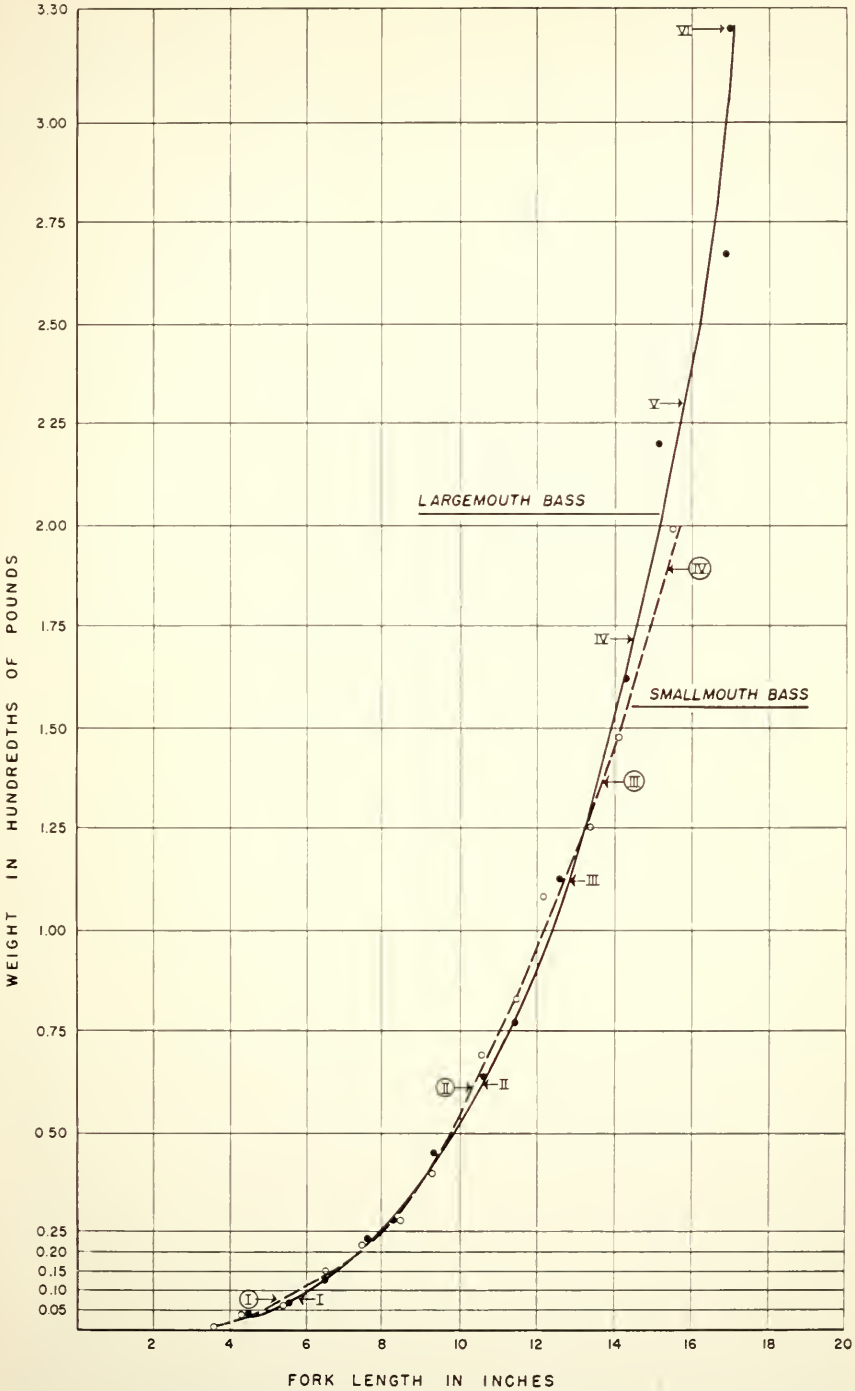


FIGURE 3. Length-weight relationships of Folsom Lake largemouth and smallmouth bass. Roman numerals show lengths and weights at each annulus.

TABLE 5

Growth Rates of Smallmouth Bass in Various Waters in the United States [1]

Water	Source	Age group I	II	III	IV	V	VI	VII
Folsom Res., California[2]	Present study	5.2	10.3	13.6	15.3			
Hiwassee Res., N. Carolina[3]	Stroud (1949)	3.6	9.1	12.5	14.0	15.4		
Norris Res., Tennessee[3]	Stroud (1948)	3.1	8.9	13.3	15.8	17.4	18.0	18.6
Oneida Lake, New York[3]	Forney (1961)	3.9	6.9	12.3	13.5	14.7	15.7	16.4
Lake Michigan, Michigan[3]	Latta (1963)	3.9	6.3	8.1	9.7	11.5	13.2	14.6
Little Miami River, Ohio[3]	Brown (1960)	2.9	5.9	8.8	11.0	12.7	13.9	14.5
Wisconsin waters[3]	Bennett (1938)	2.4	5.3	8.2	10.6	12.5	14.1	15.3

[1] Ranked according to size at Age II.
[2] Average calculated fork length.
[3] Average calculated total length.

In both species, the greatest growth in length occurs in the first year of life, and annual increment decreases in successive years. The greatest decrease in annual increment in largemouth bass occurs in the third year, while the greatest decrease in smallmouth bass growth occurs in the fourth year.

The growth of largemouth bass in Folsom Lake is intermediate in comparison with waters elsewhere in California and the United States (Table 4).

Smallmouth bass growth in Folsom Lake is comparable to that reported for southeastern waters (Stroud, 1948 and 1949), and superior to that reported in northern waters (Table 5).

Growth in Weight

The length-weight relationships for largemouth bass and smallmouth bass, respectively, are: $W = -3.43716 + 3.163 \log L$; and $W = -3.38873 + 3.125 \log L$. These are similar (Figure 3), although smallmouth bass are slightly heavier between 9.5 to 13.0 inches, possibly because of earlier sexual maturity. Above 13 inches largemouth bass are heavier.

Seven-year Growth History

The calculated growth histories of various year-classes of largemouth bass and smallmouth bass (Figure 4) show that growth rates were quite constant during the first 7 years of impoundment. Growth of successive year-classes of largemouth bass increased slightly between 1955 and 1957 and declined slightly in subsequent years. Smallmouth bass growth varied little for all year-classes since 1957. Data on the growth of older age groups of smallmouth bass from the 1955 and 1956 year-classes are lacking, but the slow second-year growth of the 1955 year-class indicates initial growth improvement like that for largemouth bass.

BLUEGILL AND RED-EAR SUNFISH

Body-Length/Scale-Length Relationships

The bluegill body-scale relationship was determined from 1,288 scale samples collected in 1961. The graph of body-scale data (Figure 5) indi-

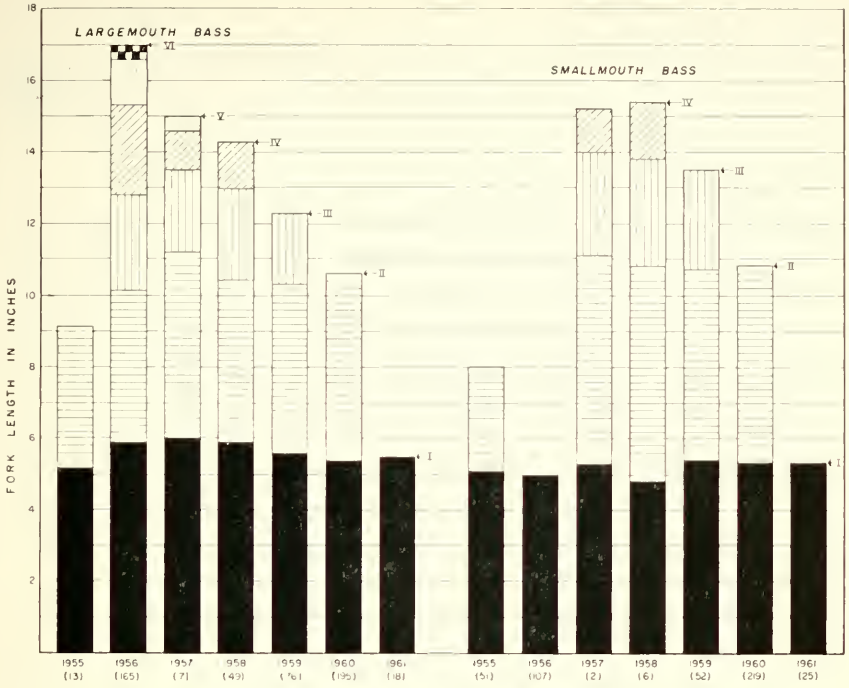


FIGURE 4. Calculated growth histories of the largemouth and smallmouth bass year-classes of Folsom Lake. Figures in parentheses indicate number of samples.

cated a linear relationship between fork length and anterior scale radius for fish longer than 1.5 inches. The straight line fitted by least squares to these data had the equation $Y = 0.94 + 0.0358X$.

For fish less than 1.5 inches FL, the direct proportion method overestimated length. An eye-fitted line was drawn for the empirical data of fish 1.5 inches and smaller, and the amount of correction required at a

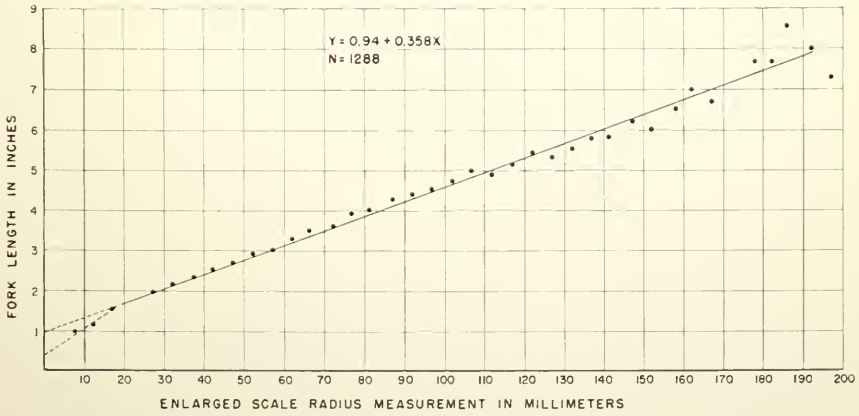


FIGURE 5. Bluegill body-length/scale-length relationship.

particular length was obtained by measuring the vertical distance between the two line segments.

The body-scale relationship for red-ear sunfish is a composit of the 187 scale samples collected in 1960, 1961, and 1962. The relationship over the length range of 1.7 to 9.9 inches was linear, and is described by the equation $Y = 0.64 + 0.0480X$.

Growth in Length

Red-ear sunfish grow more rapidly than bluegill throughout life (Tables 6 and 7). Average growth is less than 2.0 inches in the first year for both species. Red-ear sunfish growth in the second summer is nearly twice that of bluegill. At Age III red-ear sunfish average over 7 inches long while bluegill are only 5. Red-ear sunfish are over 8 inches long at the end of four growing seasons, while bluegill do not reach a comparable length until their 6th summer.

The growth of red-ear sunfish in Folsom Lake is very good in comparison with other areas (Table 8). The early growth of bluegill, on the other hand, is very slow, being comparable to growth in the northern part of its range. Growth of bluegill beyond Age III, however, is well above average, and is similar to that reported for reservoirs in Oklahoma and one in Missouri.

TABLE 6

Calculated Fork Lengths of Folsom Lake Bluegill Collected in 1957, 1960, 1961, and 1962

Age group	*Number of fish*	*Mean fork length at capture (inches)*	*Mean calculated fork length in inches at end of year of life*					
			1	*2*	*3*	*4*	*5*	*6*
I	141	3.5	1.4					
II	133	5.0	1.4	3.3				
III	72	6.3	1.2	2.7	4.5			
IV	26	7.5	1.5	3.2	5.3	6.9		
V	15	8.1	1.5	3.3	5.5	7.0	7.9	
VI	2	8.9	1.4	4.2	6.1	7.5	8.3	8.7
Mean calculated length			1.4	3.1	4.8	7.0	7.9	8.7
Mean annual increment			1.4	1.7	1.7	2.2	0.9	0.8
Number of fish			389	248	115	43	17	2

TABLE 7

Calculated Fork Lengths of Folsom Lake Red-ear Sunfish Collected in 1960, 1961, and 1962

Age group	*Number of fish*	*Mean fork length at capture (inches)*	*Mean calculated fork length in inches at end of year of life*			
			1	*2*	*3*	*4*
I	79	4.1	1.9			
II	75	5.9	1.8	4.7		
III	21	7.7	1.9	5.1	7.5	
IV	12	9.0	1.9	5.5	7.5	8.8
Mean calculated length			1.9	4.9	7.5	8.8
Mean annual increment			1.9	3.0	2.6	1.3
Number of fish			187	108	33	12

TABLE 8

Growth Rates of Bluegill and Red-ear Sunfish in Various Waters in the United States [1]

Water	Source	Age group I	II	III	IV	V	VI
Bluegill							
Clear Lake, California[2]	Murphy (1951)	2.3	4.1	6.5	8.1	8.9	9.1
Oklahoma Reservoirs (State average)[3]	Jenkins *et al.* (1955)	3.5	5.2	6.2	7.2	9.5	--
Clearwater Res., Missouri[3]	Lane (1954)	2.5	4.2	5.6	6.6	--	--
Northern Wisconsin (average)[3]	Snow *et al.* (1960)	2.1	3.8	5.0	5.7	6.5	7.1
Folsom Lake, California[4]	Present study	1.4	3.1	4.8	7.0	7.9	8.7
Lake Murphysboro, Ohio[3]	Louder and Lewis (1957)	1.6	2.8	4.0	5.0	5.7	5.9
Red-ear sunfish							
Folsom Lake, California[4]	Present study	1.9	4.9	7.5	8.8	--	--
Oklahoma Reservoirs (State average)[3]	Jenkins *et al.* (1955)	3.6	5.7	7.1	8.2	9.3	10.1
Reelfoot Lake, Tennessee[5]	Schoffman (1939)	4.3	6.0	6.9	7.5	8.1	--
Lake Murphysboro, Ohio[3]	Louder and Lewis (1957)	1.8	3.8	5.3	6.5	7.4	8.8

[1] Ranked according to size at Age II.
[2] Average fork length at capture.
[3] Average total length in inches.
[4] Average fork length in inches.
[5] Average total length at capture.

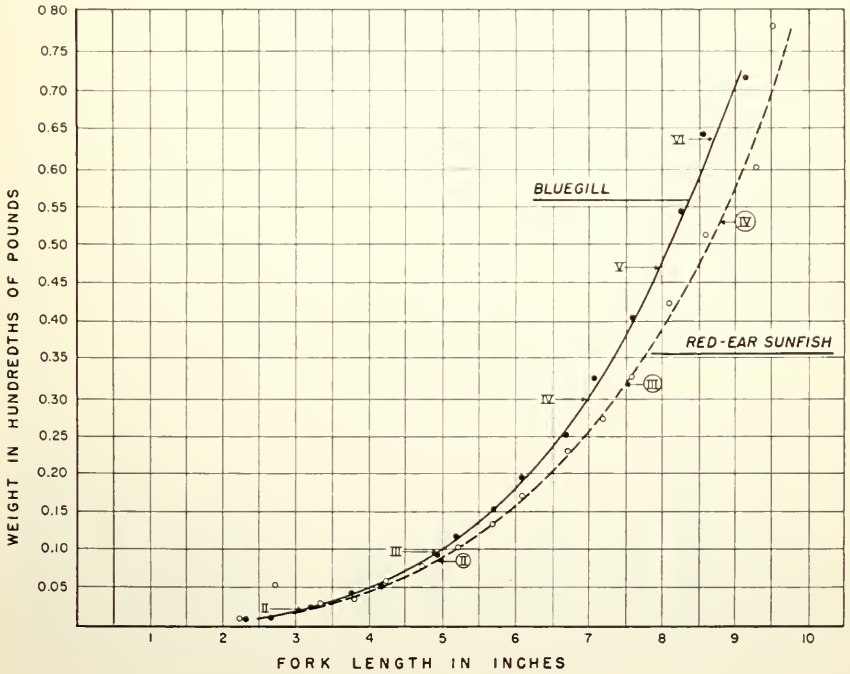


FIGURE 6. Length-weight relationships of Folsom Lake bluegill and red-ear sunfish. Roman numerals show lengths and weights at each annulus.

Growth in Weight

The length-weight relationships for bluegill and red-ear sunfish, calculated in the same manner as for largemouth bass and smallmouth bass, are described by the equation Log $W = -3.16513 + 3.129$ Log L for bluegill; Log $W = -2.87068 + 2.712$ log L for red-ear sunfish. Bluegill are relatively heavier for their length than are red-ear sunfish throughout their life (Figure 6).

Seven-year Growth History

The growth of the various year-classes of bluegill showed a precipitous decline between 1955 and 1957 followed by a mere gradual decline in recent years (Figure 7). The growth increment of 1956 yearling bluegills was less than half that of the 1955 yearlings and accounted for most of the decline. Growth increments during the second and third summers have remained relatively stable since 1956.

The rapid decline in growth of Folsom Lake bluegills parallels that noted for the early years at Millerton Lake, another large fluctuating

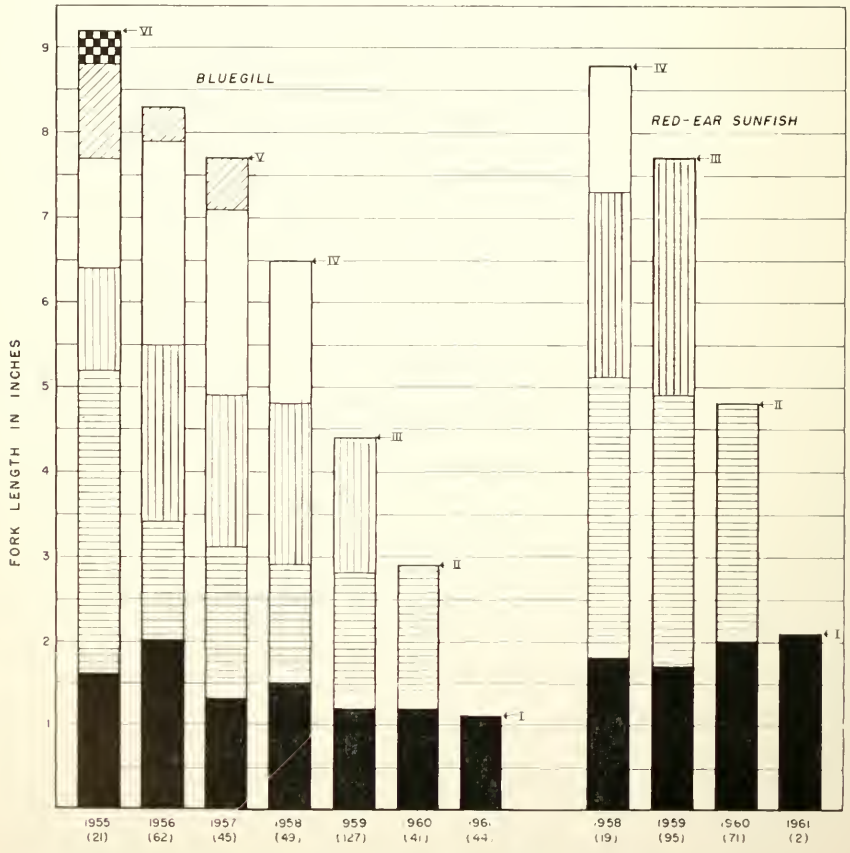


FIGURE 7. Calculated growth histories of the bluegill and red-ear sunfish year-classes of Folsom Lake. Figures in parentheses indicate number of samples.

California reservoir. Catches of bluegills averaging 6 inches long were common during the initial 2 years after impoundment (Dill, 1946). By 1951, the average had declined to about 5.5 inches (Abell and Fisher, 1953). In 1962, an intensive sampling program, using a variety of methods, resulted in a catch of nearly 2,000 bluegills, only 2 of which were larger than 6 inches. Unpublished growth data on Millerton Lake bluegill show slow growth for all age groups. Fish reached 6 inches only in their 5th summer.

Information on the growth of red-ear sunfish is available only for 1958 through 1961 (Figure 7), since red-ear sunfish were not planted in Folsom Lake until 1957. No significant changes in the growth are evident.

ACKNOWLEDGMENTS

Many persons contributed to this study. The 1957 scale collections were made by Central Valleys Hatchery personnel during a routine management survey at the lake. Later collections were made by warm-water research staff members. Frederick A. Meyer and Michael L. Johnson made some of the initial age determinations.

I thank Patrick Tomlinson for calculating the length-weight relationships, and William Schafer for the scale and otolith photographs.

Harold Chadwick and later Charles von Geldern supervised the field work. Both critically reviewed the manuscript and offered helpful advice.

REFERENCES

Abell, Dana L. and Charles K. Fisher. 1953. Creel census at Millerton Lake, California, 1945–1952. Calif. Fish and Game 39 (4) : 463–484.

Beckman, William C. 1949. The rate of growth and sex ratio for seven Michigan fishes. Amer. Fish Soc., Trans., 76 (1946) : 63–81.

Beland, R. D. 1954. Report on the fishery of Lake Havasu. Calif. Dept. Fish and Game, Inland Fish. Br. Admin. Rept. (54–17) : 1–42 (mimeo.).

Bennett, George W. 1937. The growth of large-mouthed black bass, *Huro salmoides* (Lacépède), in the waters of Wisconsin. Copeia 1937 (2) : 104–118.

———— 1938. Growth of the small-mouthed black bass, *Micropterus dolomieu* Lacépède, in Wisconsin waters. Copeia 1938 (4) : 157–170.

Brown, Edward H., Jr. 1960. Little Miami River headwater-stream investigations. Ohio Dept. Nat. Res., Final Report D-J Project F-1-R, 143 p.

Dill, W. A. 1944. The fishery of the Lower Colorado River. Calif. Fish and Game, 30 (3) : 109–211.

———— 1946. A preliminary report on the fishery of Millerton Lake, California. Calif. Fish and Game, 32 (2) : 49–69.

Fisher, Charles K. 1951. Progress report number 2 on the fishery of Millerton Lake. Calif. Dept. Fish and Game, Inland Fish. Br. Admin. Rept., (51–31) : 1–41 (mimeo.).

Forney, John L. 1961. Growth, movements, and survival of smallmouth bass (*Micropterus dolomieui*) in Oneida Lake, New York. New York Fish and Game Jour., 8 (2) : 88–105.

Jenkins, Robert, and Gordon Hall. 1953. The influence of size, age, and condition of waters upon the growth of largemouth bass in Oklahoma. Okla. Fish. Res. Lab. Rept., (30) : 1–43.

Jenkins, Robert, Ronald Elkin, and Joe Finnell. 1955. Growth rates of six sunfishes in Oklahoma. Okla. Fish. Res. Lab. Rept., (49) : 1–73.

Kimsey, J. B. and R. R. Bell. 1955. Observations on the ecology of the largemouth bass and the tui chub in Big Sage Reservoir, Modoc County, Calif. Dept. Fish and Game, Inland Fish. Br., Admin. Rept. (55–15) : 1–17 (mimeo.).

LaFaunce, Don A., J. B. Kimsey, and Harold K. Chadwick. 1964. The fishery at Sutherland Reservoir, San Diego County, California. Calif. Fish and Game, 50 (4) : 271–291.

Lane, Charles E., Jr. 1954. Age and growth of the bluegill, *Lepomis m. macrochirus* (Rafinesque), in a new Missouri impoundment. Jour. Wildl. Mgt., 18 (3) : 358–365.

Latta, William C. 1963. The life history of the smallmouth bass, *Micropterus d. dolomieui*, at Waugoshance Point, Lake Michigan. Mich. Dept. of Cons., Bull. Inst. Fish. Res., (5) : 1–56.

Louder, Darrell E., and William M. Lewis. 1957. Study of a stocking of the redear and bluegill in southern Illinois. Prog. Fish-Cult., 19 (3) : 140–141.

Murphy, Garth I. 1951. The fishery of Clear Lake, Lake County, California. Calif. Fish and Game, 37 (1) : 439–484.

Rawstron, R. 1964. Limnology of Folsom Lake. 1961–63. Calif. Dept. Fish and Game, Inland Fish. Br., Admin. Rept., (64-13) : 1–9 (mimeo).

Schoffman, Robert J. 1939. Age and growth of the red-eared sunfish in Reelfoot Lake. Tenn. Acad. Sci., Jour., 14 (1) : 61–71.

Snow, Howard, Arthur Ensign, and John Klingbiel. 1960. The bluegill, its life history, ecology, and management. Wisc. Cons. Dept. Publ., (230) : 1–16.

Sprugel, George, Jr. 1954. Growth of bluegills in a new lake, with particular reference to false annuli. Am. Fish Soc., Trans., 83 (1953) : 58–75.

Stroud, Richard H. 1948. Growth of the bases and black crappie in Norris Reservoir, Tennessee. Tenn. Acad. Sci., Jour., 23 (1) : 31–99.

_____. 1949. Rate of growth and condition of game and pan fish in Cherokee and Douglas reservoirs, Tennessee, and Hiwassee Reservoir, North Carolina. Tenn. Acad. Sci., Jour., 24 (1) : 60–74.

von Geldern, C. E., Jr. 1964. Distribution of white catfish, *Ictalurus catus*, and rainbow trout, *Salmo gairdnerii*, in Folsom Lake, California, as determined by gill netting from February through November, 1961. Calif. Dept. Fish and Game, Inland Fish. Br., Admin. Rept., (64-15) : 1–8 (mimeo).

Wohlschlag, Donald E., and Chester A. Woodhull. 1953. The fish populations of Salt Springs Valley Reservoir, Calaveras County, California. Calif. Fish and Game, 39 (1) : 5–44.

Calif. Fish and Game, 52(1): 17–27. 1966.

RENESTING OF DUCKS AT MOUNTAIN MEADOWS, LASSEN COUNTY, CALIFORNIA[1]

ELDRIDGE G. HUNT and WILLIAM ANDERSON
Game Management Branch
California Department of Fish and Game

During the spring and summer of 1956, a study was completed on an area approximating 1,000 acres of marsh and meadowland at Mountain Meadows Reservoir, Lassen County, California, to obtain information on the renesting habits of ducks.

In all, 110 ducks were captured on their nests, banded, colormarked, and released. Their eggs were removed to achieve the effect of nest destruction. Nineteen of the marked ducks (six cinnamon teal, eight ring-necked ducks, and five lesser scaup) were found renesting. Four of the renesting ducks (one cinnamon teal, one ring-necked duck, and two lesser scaup) were known to have renested twice. One scaup renested a third time.

INTRODUCTION

The subject of nest losses among ducks has been studied extensively. However, only meager information had been published on the subsequent activities of ducks that had suffered such losses, until Sowls (1955) made comprehensive renesting studies at Delta Marsh in southern Manitoba from 1946 through 1950. It was suspected that renesting was a common occurrence among ducks on California breeding grounds, but the frequency of renesting by each species and the contribution to waterfowl production were questions that have not been thoroughly answered.

During the spring and summer of 1956, the California Department of Fish and Game conducted a study at Mountain Meadows Reservoir, Lassen County, California, to add to existing knowledge of duck renesting habits. This investigation was preceded by a pilot study in 1955 (Hunt, unpublished) to determine the suitability of the study site and to develop trapping and marking techniques. Waterfowl production in this marsh was evaluated during a detailed investigation in 1954 (Hunt, unpublished).

Mountain Meadows Reservoir was selected because it fulfilled four requirements: (i) it supported an adequate number of nesting ducks that could be nest-trapped, (ii) it was isolated from other nesting areas, (iii) it was readily accessible throughout the nesting season, and (iv) it was easily divisible into representative study units.

The study site was near the town of Westwood at about 5,000 feet elevation. Reservoir and bordering marsh and meadowland comprised approximately 11,000 acres (Figure 1). Within this site, 1,000 acres with suitable vegetative cover was selected as a study area. It is traversed by Goodrich Creek and several other small streams and irrigation ditches.

[1] A contribution of Federal Aid in Wildlife Restoration, California Project W-30-R, "Waterfowl Studies." Submitted for publication August 1965.

2—57921

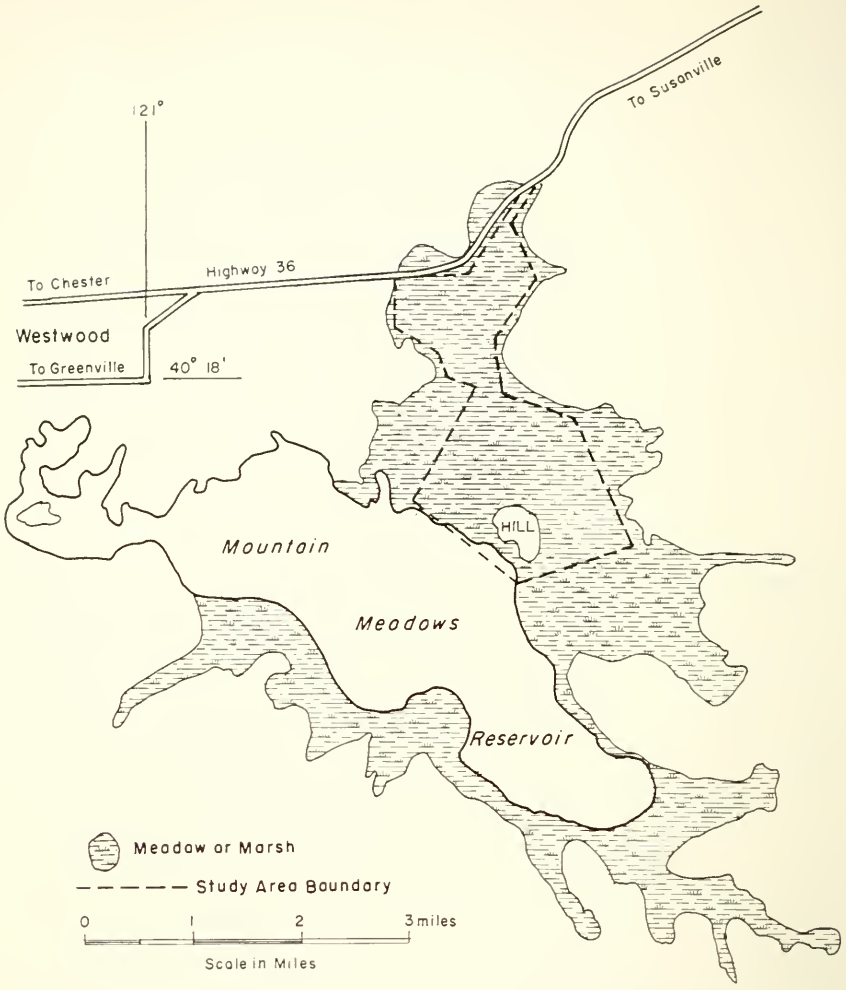


FIGURE 1. Mountain Meadows study area, Lassen County, California. *Drawn by Cliffa Corson.*

The dominant plants in the marsh are sedge (*Carex* sp.) and wire rush (*Juncus balticus*). In fields and meadows with high water tables, various grasses and herbs comprise the dominant cover. The principal economic use of the area was cattle grazing.

A state trapper was assigned to trap predators on and adjacent to the study area, since the pilot study had shown that nest predation by coyotes and skunks was a potential menace to the success of the project.

NESTING CONDITIONS

Duck nesting at Mountain Meadows usually begins in late April or early May. In 1954, the first duck nest was found on April 26; in 1955, on May 12; and in 1956, on May 16. Mallards (*Anas platyrhynchos*)

usually comprise the bulk of the early nesters, but during 1956 the first nests found were those of cinnamon teal (*Anas cyanoptera*). This may be explained by the flooded condition of the marsh area which had inundated preferred mallard habitat. Apparently, most of the mallards were able to postpone nesting until conditions improved. Cinnamon teal habitually nest in the more upland grassy cover while ring-necked ducks (*Aythya collaris*) and lesser scaup (*Aythya affinis*) construct their nests on matted vegetation in the marsh.

In 1955, most nesting occurred in May and June and was over by mid-July. In 1956, it was nearly mid-June before the water receded, and cover became dense enough to provide adequate nesting conditions for most species. The study was completed on August 10.

METHODS

Nests were found by a systematic search of study units by three to six men with the aid of a dog. Active nests were marked to insure relocation.

Most nest trapping was accomplished with modified Bailey beaver traps designed by A. W. Miller (Figure 2). The Miller trap consists of a hoop which is held flat to an "A" frame in set position and flips 180 degrees when sprung. The hoop is spanned by 2-inch mesh netting and held in position by a trigger mechanism mounted on the "A" frame. The trap was sprung by striking the trigger with rifle fire.

In initial trapping attempts some female ducks escaped from under the hoop, and it was necessary to devise a lock to hold the hoop flush with the ground after the trap was sprung. An ordinary rat trap

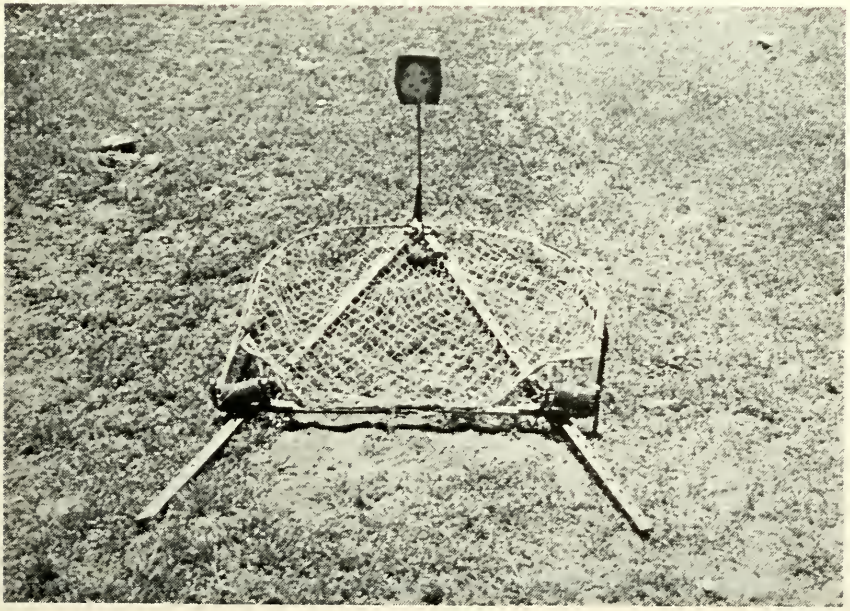


FIGURE 2. Modified Bailey beaver trap used for capturing nesting waterfowl. *Photograph by William Anderson.*

equipped with an enlarged "L" shaped trigger and extended catching bars was pegged to the ground in a position to catch the hoop and keep it firmly pressed to the ground (Figure 3).

In principle the Miller trap resembles the nest trap described by Salyer (1962) but is believed to have one advantage. Because it is set in a horizontal position, it is possible to conceal the major portion of the trap with freshly cut vegetation and thereby minimize the chances of nest desertion. Ten Miller traps were used.

A dip net with a long aluminum handle was sometimes employed. Where dip netting was successful in capturing an incubating duck it

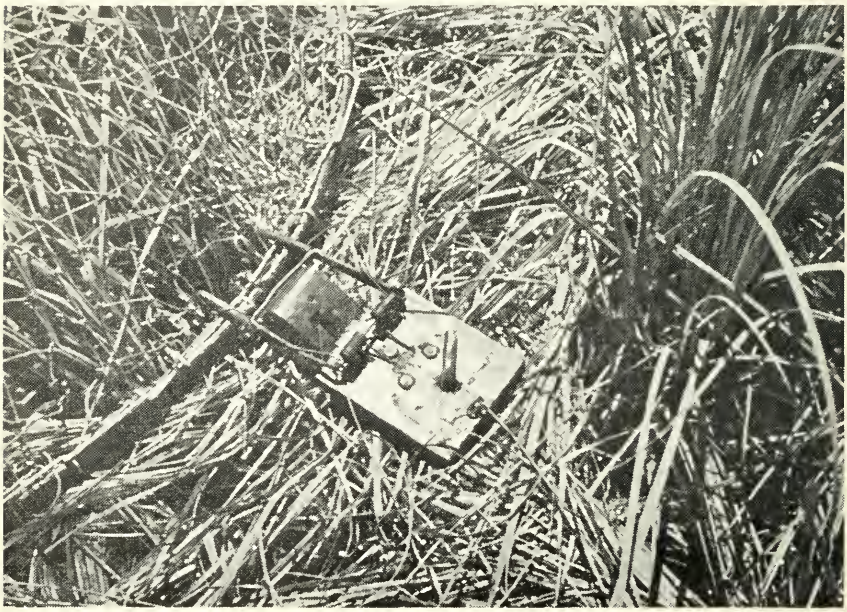


FIGURE 3. Trap lock mechanism used on nest trap. *Photograph by William Anderson.*

was less time-consuming, but it had the disadvantages of demanding a close approach and knowledge of the exact nest location. The Miller trap proved to be a generally more successful method, but the dip net was used to supplement the catch made by the Miller traps.

Each trapped bird was banded with a standard U.S. Fish and Wildlife Service leg band and color-marked. The leg band served as a permanent means of identification and the color marking as a temporary means of recognition. Three colors were used—red, yellow, and white. These colors were applied to feathers on any one or all of four parts of the bird's plumage: nape, wings, and tail. This provided enough color combinations for field identification of over 100 individual ducks of each species.

Spray-can lacquer (Aero Gloss, Pactra Chemical Company of Los Angeles) was used for color marking. It was applied in two coats, and application and drying required 20 to 30 minutes before the bird could be released (Figure 4).

Marking by this method was far from satisfactory. The spray held up reasonably well on the dabbling ducks but was unsatisfactory for marking diving ducks. Only one of the divers retained enough paint on its feathers 1 week after marking to be recognized. To assure identity of a duck that could not be recognized by its colored plumage, it was necessary to retrap the bird and examine the numbered leg band.

After trapping and marking the incubating duck, the eggs were removed to simulate nest destruction. Eggs collected in this manner were hatched in incubators to minimize loss of production.

The location of each successfully trapped nest and all renests were plotted on a map for use in the correlation of renesting attempts and to provide a graphical record.

FIGURE 4. Color-marking a lesser scaup. *Photograph by William Anderson.*

NEST TRAPPING RESULTS

Two hundred ninety-seven duck nests representing eight species were found during the study period (Table 1). These were mallard, cinnamon teal, pintail (*Anas acuta*), gadwall (*Anas strepera*), ring-necked duck, lesser scaup, ruddy duck (*Oxyura jamaicensis*), and redhead (*Aythya americana*).

A few nests had already hatched by the time they were located, and in some instances hens eluded trapping attempts but persisted in returning to the nest to complete incubation.

Nest destruction, 21.9 percent, was mainly the result of predation by striped skunks (*Mephitis mephitis*), coyotes (*Canis latrans*), and possibly other animals. Flooding and trampling by cattle accounted for a few nest losses. Predation was not excessive when compared to other situations (Hunt, 1954, unpublished; Anderson, 1956).

TABLE 1

Results of Trapping Attempts, Mountain Meadows Reservoir, 1956

Species	*No. of nests*	*Successfully trapped*	*Not trapped*		
			Hatched	*Destroyed*	*Deserted*
Mallard	58	10	5	13	30
Cinnamon teal	116 *	53	7	28	28
Pintail	16	6	0	7	3
Gadwall	4	2	0	1	1
Ring-necked duck	23 *	19	0	1	3
Lesser scaup	68 *	35	1	13	19
Ruddy	7	2	2	0	3
Redhead	5	1	1	2	1
Totals	297	128	16	65	88
Percent	100	43.2	5.4	21.9	29.5

* Includes renests.

Desertion in the 1956 study, 29.5 percent, was about 10 percent higher than recorded in 1954. This increase was probably the result of disturbance of normal nesting activities by nest-trapping operations. In spite of these problems, trapping was successful on 43.2 percent of the nesting ducks located.

Trapping procedures and intervals between setting and springing of the traps had to be adapted to prevailing conditions, such as cover type and density, and the tolerance of individual birds. Thus in early stages of incubation, birds were generally less tolerant of intrusion and of changes in the immediate vicinity of the nest than they were toward the end of the incubation period. In some instances, hens were trapped on the nest within 2 hours after the traps were set. Some species, notably mallards, were difficult to trap and deserted readily.

Success with the Miller traps varied considerably since their efficiency and speed depended on the strength of the springs. All were made from old, used beaver traps. Only three of the traps were fast enough to catch mallards. The other seven were used primarily in capturing the slower-flushing species.

There were numerous examples of ducks returning to nests after unsuccessful trapping attempts. One female ring-necked duck was caught under a Miller trap and escaped six times before she was finally captured and marked. A trap was sprung by cattle three times over a mallard nest. The bird was not caught but returned to the nest each time, worked the eggs through the netting of the trap, and continued incubation. Cinnamon teal and scaup incubated eggs that were covered with netting when the traps were accidentally sprung, possibly during the absence of the hen. Traps were frequently sprung by cattle nuzzling the trigger.

RENESTING

The ring-necked duck was the most persistent renester. Of the 10 birds trapped and marked, 8 renested. One was found dead on the study area. Cinnamon teal and lesser scaup also renested. Six cinnamon teal of 48 trapped and 5 lesser scaup of 31 trapped were known to have renested. One lesser scaup renested three times and another twice. One cinnamon teal and one ring-necked duck renested twice (Table 2).

TABLE 2

Renesting Records, Mountain Meadows Reservoir, 1956

Species	*No. of nests found*	*Trapped and marked*	*1st renesting*	*2nd renesting*	*3rd renesting*
Mallard	58	10			
Cinnamon teal	116	48	6	1	
Pintail	16	6			
Gadwall	4	2			
Ring-necked duck	23	10	8	1	
Lesser scaup	68	31	5	2	1
Ruddy	7	2			
Redhead	5	1			
Totals	297	110	19	4	1

It would be presumptuous to infer that all renests were accounted for. Many unknown factors were involved. Some renests undoubtedly were missed by the study crew; some nests found for the first time could have been renests; and some hens probably renested off the study area. Sowls (1955) pointed out that mallards were difficult to handle, deserted readily, and did not offer good opportunity for comparison. This was true in the present study. In addition, we believe that renests of cinnamon teal were more difficult to find than other duck nests because of better nest concealment.

Keith (1961) stated that unsuccessful mallards in southeastern Alberta renested at least once, and 63 percent of the mallard hens having their first nest destroyed attempted another renesting. He claimed that overall renesting rates for other species were: gadwall, 82 percent; shoveler, 75 percent; blue-winged teal, 55 percent; and scaup, 39 percent. These figures were apparently based on visual estimates and were not substantiated through trapping and marking the hens.

The appearance of renests and first nests was usually similar. In general, the renests were as well concealed and as well constructed as first nests. In most cases, there was a slight reduction in the number of eggs in renests as compared to first nests, but this reduction was insufficient to be used as a criterion for distinguishing first nests from renests (Table 3). There was a difference among individuals of the same species in the number of eggs laid in first nests and renests. The period of the nesting season when a nest is found is not a valid method for classifying nests as first nests or renests. An early-nesting female could be renesting before another of the same species had started incubating on her first nest.

The time between destruction or desertion of the first nest and laying of the first egg in the second nest is the renesting interval. The shortest renesting interval observed was 5 days and the longest, 27 days.

According to Sowls (1955), the renesting interval is determined by the degree of incubation of the eggs of the first nest at the time of destruction. For example, a duck that has lost its nest after the eggs have been incubated for 1 day should be likely to renest sooner than one that has suffered nest loss after 10 days of incubation. The renesting interval of cinnamon teal at Mountain Meadows corresponded generally to this concept. The renesting intervals of two cinnamon teal whose

TABLE 3

Number of Eggs, Mountain Meadows Reservoir, 1956

Species	*Eggs in first nest*	*Eggs in second nest*	*Eggs in third nest*	*Eggs in fourth nest*
Cinnamon teal	9	7		
Cinnamon teal	11	9		
Cinnamon teal	11	7	9	
Cinnamon teal	7	9		
Cinnamon teal	11	8		
Cinnamon teal	11	10		
Average	10.0	8.3		
Ring-necked duck	9	7		
Ring-necked duck	9	9		
Ring-necked duck	8	8		
Ring-necked duck	9	6		
Ring-necked duck	7	8		
Ring-necked duck	7	8		
Ring-necked duck	7	8	7	
Ring-necked duck	7	8		
Average	7.9	7.8		
Lesser scaup	12	11		
Lesser scaup	11	9	8	7
Lesser scaup	9	7	7	
Lesser scaup	9	9		
Lesser scaup	12	8		
Average	10.6	8.8	7.5	

nests were destroyed before incubation began were 5 and 6 days respectively (Table 4). However, there was no similar correlation between incubation and renesting interval in ring-necked ducks and lesser scaup. Eggs in three nests of each of these two species were removed before the beginning of incubation, and the renesting interval varied from 5 to 27 days. Possibly some hens that were thought to have long renesting intervals made abortive nesting attempts before their renests were discovered.

The stage of incubation was determined by breaking one egg and ascertaining the degree of embryonic development by the method of Romanoff, Bump, and Holm, 1938.

Four renesting females laid three fertile clutches of eggs each. This was accomplished by one cinnamon teal, two lesser scaup, and one ring-necked duck. One scaup laid four clutches of eggs, but the last was infertile. Two other clutches of infertile eggs laid by a renesting scaup and a ring-necked duck, were found. The first of the infertile clutches was started July 9; the second, July 15; and the third, July 21. Although this was considered late for renesting, four renests that were started after July 10 had fertile eggs. Thus, the starting date of renesting attempts could not be used as a criterion in judging clutch fertility.

The distances between first nests and renests of cinnamon teal averaged about 160 yards. The corresponding distances for ring-necked ducks and lesser scaup averaged 591 and 464 yards, respectively. The greatest distance between a first nest and a renest was 1,450 yards; the shortest, 65 yards.

TABLE 4

Renesting Intervals, Mountain Meadows Reservoir, 1956

Species	*Days of incubation*	*Renesting interval (days)*
Cinnamon teal	24	19
Cinnamon teal	5	7
Cinnamon teal	12	21
Cinnamon teal	0	6
Cinnamon teal	9	27
Cinnamon teal	4 and 0	18 and 5 *
Ring-necked duck	6	18
Ring-necked duck		21
Ring-necked duck	1	15
Ring-necked duck	4	8
Ring-necked duck	0	14
Ring-necked duck	0	19
Ring-necked duck	0	13
Ring-necked duck	2 and 6	17 and 11 *
Lesser scaup	1 and 3	11 and 6 *
Lesser scaup	0	21
Lesser scaup	9	20
Lesser scaup	16	14
Lesser scaup	0, 0, and 1	5, 10, and 7 †

* Renested twice.
† Renested 3 times.

DISCUSSION

The 1956 duck nesting season was probably a better-than-average production year at Mountain Meadows. High water and general weather conditions caused a comparatively late start in nesting activities of most species. This was apparently compensated for by retention of lush nesting cover during midsummer, encouraging renesting of ducks.

Although the positive information on renesting of ducks in this study is limited to three species, these were species that had received little attention in the past. The cinnamon teal may well be regarded as the western counterpart of the blue-winged teal (*Anas discors*), and so far as renesting data are concerned, blue-winged teal in the Delta Marsh of Manitoba and cinnamon teal in the present study followed markedly similar patterns. The data pertaining to the renesting persistence of the ring-necked duck and the lesser scaup, probably constitute the most important information resulting from this study.

Rogers (1964) asserted that the effect of nest predation on scaup production is especially severe because few hens renest if the first nest is lost. However, Rogers's study was conducted in southwestern Manitoba during years of critical drought.

In view of previously published data on the distribution of birds in California, it is noteworthy that 23 nests of ring-necked ducks (Figure 5) and 68 nests of lesser scaup were observed at Mountain Meadows. Grinnell and Miller (1944) recognized only one substantiated breeding record of the ring-necked duck within the state, "a juvenal specimen taken at Rowland's Marsh, Lake Tahoe, El Dorado County, August 24, 1926." The lesser scaup is known to nest regularly on the Lower Klamath National Wildlife Refuge, Siskiyou County, where 10 nests

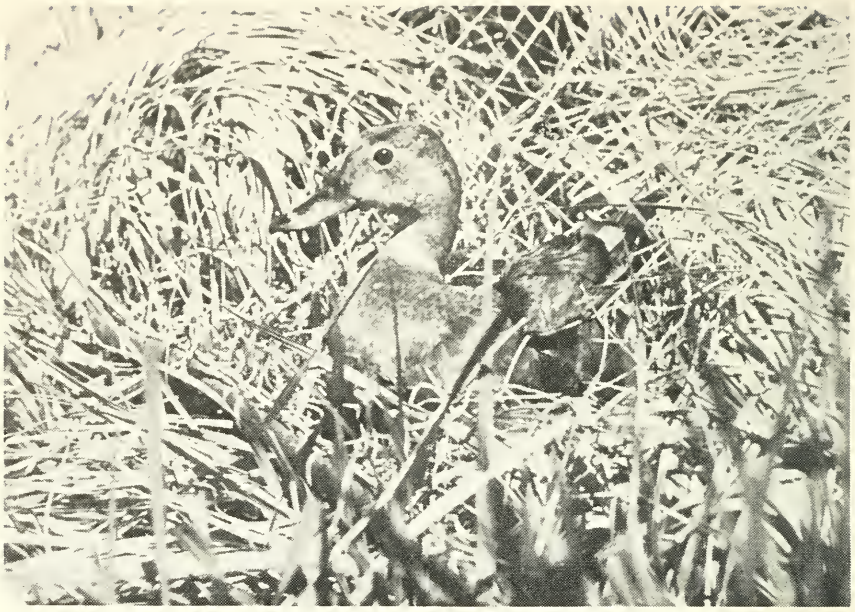


FIGURE 5. Ring-necked duck in nest trap. *Photograph by William Anderson.*

were found during 1952 (Miller and Collins, 1954) and 24 nests were located during 1957 (Rienecker and Anderson, 1960).

In addition to further study on variable conditions affecting renesting, information is needed on the renesting habits of the more heavily-hunted species such as the mallard.

ACKNOWLEDGMENTS

The Shasta Forest Company of Redding, California, granted the Department of Fish and Game permission to conduct waterfowl studies on lands under their administration.

Thanks are extended to the following members of Project 30-R: Warren C. Rienecker for operating the incubators and raising the ducklings; Dale Horn for recording the data obtained during the study and assisting with the nest trapping; Richard Wheeler, Victor Simpson, Mathew Keller, J. R. LeDonne, and A. E. Naylor for assisting in collection of the field data.

We are indebted to William Thornton for his services in trapping nest predators on the study area, and to Frank M. Kozlik for helping with the manuscript as well as with field work.

REFERENCES

Anderson, William. 1956. A waterfowl study on the grasslands of Merced County, California. Calif. Fish and Game, 42(2): 117–130.

Atwater, Melvin G. 1959. A study of renesting in Canada geese in Montana. Jour. Wildl. Mgmt., 23(1): 91–97.

Grinnell, Joseph, and Alden H. Miller. 1944. The distribution of the birds of California. Pacific Coast Avifauna, (27): 1–608.

Keith, Lloyd B. 1961. A study of waterfowl ecology on small impoundments in southeastern Alberta. Wildl. Monogr., (6) : 1–88.

Miller, A. W., and B. D. Collins. 1954. A nesting study of ducks and coots on Tule Lake and Lower Klamath National Wildlife Refuges. Calif. Fish and Game, 40(1) : 17–37.

Mosby, Henry S. 1960. Manual of investigational techniques. The Wildlife Society, sec. 10 :13.

Rienecker, W. C., and William Anderson. 1960. A waterfowl nesting study on Tule Lake and Lower Klamath National Wildlife Refuges, 1957. Calif. Fish and Game, 46(4) : 481–506.

Rogers, John P. 1960. Effect of drought on reproduction of the lesser scaup. Jour. Wildl. Mgmt., 28(2) : 213–222.

Romanoff, Alexis L., Gardiner Bump, and Earl Holm. 1938. Artificial incubation of some upland game birds' eggs. New York State Cons. Dept., Albany, N.Y.

Salyer, James W. 1962. A bow-net trap for ducks. Jour. Wildl. Mgmt., 26(2) : 219–221.

Sowls, Lyle K. 1955. Prairie ducks. Wildl. Mgmt. Institute, the Stackpool Company, Harrisburg, Pa., 193 p.

Calif. Fish and Game, 52(1) : 28–48. 1966.

THE MARINE ENVIRONMENT IN THE VICINITY OF THE ORANGE COUNTY SANITATION DISTRICT'S OCEAN OUTFALL[1]

CHARLES H. TURNER, EARL E. EBERT
and ROBERT R. GIVEN[2]

Marine Resources Operations
California Department of Fish and Game

During January and February 1965, California Department of Fish and Game biologist-divers made an ecological investigation of the ocean floor in the vicinity of the Orange County ocean outfall. This study, conducted for the State Water Quality Control Board, describes the (i) animal assemblages present; (ii) the substrate characteristics and (iii) the physical conditions (temperature and clarity) of the water.

The 10 stations occupied on the ocean floor included 7 "sampling stations" used by the County in their continuous monitoring program, the outfall terminus, a mid-point on the outfall pipe, and a nearby artificial fishing reef.

The faunistic assemblages observed at each station appeared typical for these depths and substrates with two exceptions: (i) a reduced number of species was encrusting the last 100 feet of the outfall pipe compared to the central section, and (ii) considerably fewer kinds and numbers of organisms were observed on the artificial reef than we have seen on artificial reefs which had been submerged in other areas for similar periods at similar depths.

We recommend additional diving surveys, conducted at least semi-annually, to define the full effects of this outfall's effluent on the environment.

INTRODUCTION

The California Department of Fish and Game and the State Water Quality Control Board (through Regional Board #8—Santa Ana River Basin) entered into an agreement on 20 November 1964, whereby Department biologist-divers would make an ecological investigation of the ocean floor in the vicinity of the Orange County Sanitation Districts' ocean outfall. Biologist-divers would occupy sampling stations on the ocean floor and determine at each: (i) the number and diversity of plant and animal life, (ii) substrate characteristics, and (iii) physical conditions (temperature and clarity) of the water. The plant and animal communities on the rocks covering the outfall pipe were to be compared with the flora and fauna living on a nearby artificial reef.

We anticipate that the results of this study will assist the Regional Board in evaluating the effects of submarine sewage disposal on the beneficial uses of the adjacent waters.

THE STUDY AREA

The Orange County Sanitation District's ocean outfall is approximately 1½ miles NW of the City of Newport Beach, near the mouth of the Santa Ana River. The outfall pipe extends approximately 7,000

[1] Submitted for publication 29 June 1965.
[2] Now with Allan Hancock Foundation, University of Southern California.

feet seaward, in a southwesterly direction, across a gently sloping sand bottom, terminating at a depth of 50 feet.

During our survey, we located an area of low mudstone-siltstone shelves approximately 500 feet NW of the outfall pipe in 40 feet of water. On one brief dive, we determined that the shelves were subjected to sanding, but still supported lush gorgonian growths and were covered with dead shells of rock-boring piddocks and common Washing-

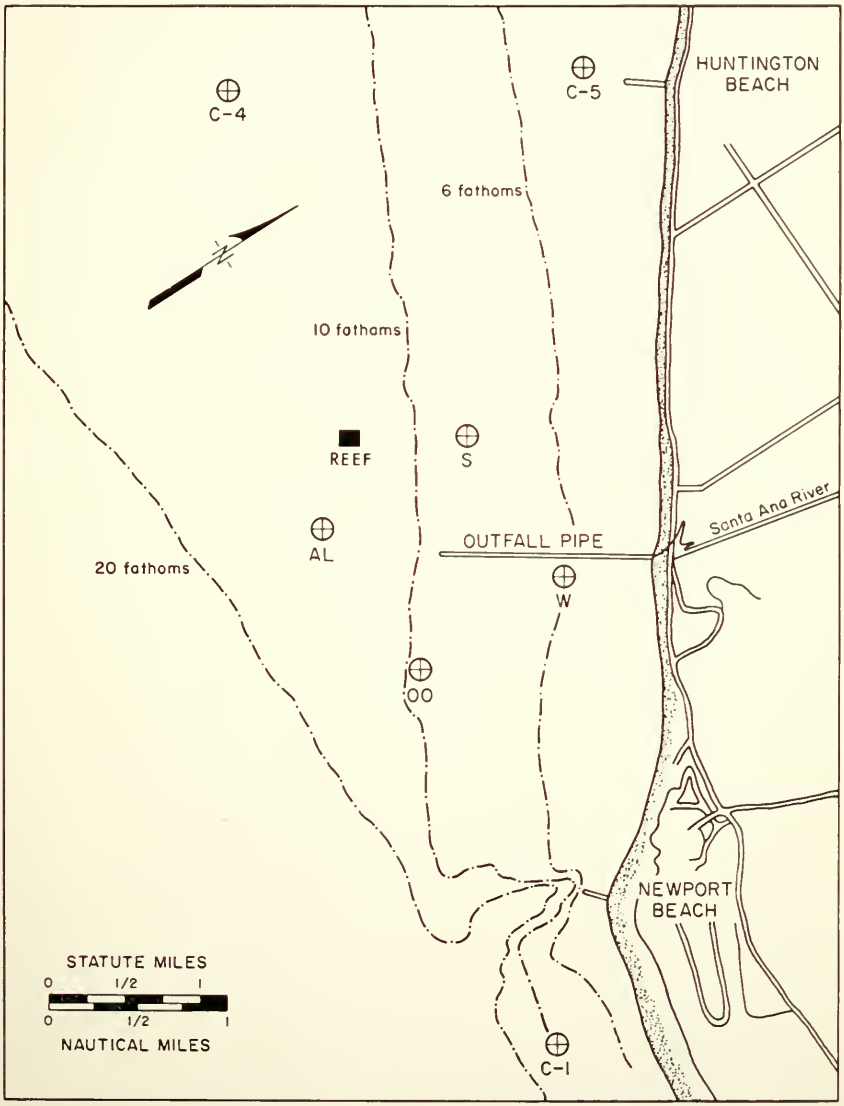


FIGURE 1. Location chart and stations surveyed—Orange County outfall survey—January and February, 1965.

ton clams. Because of extreme turbidity, we did not ascertain the extent of the shelf area nor assess the biota present.

To retain continuity between studies around this outfall, we occupied sites at seven reference points designated as "sampling stations" by the County in their continuous monitoring program (Figure 1). Our four "offshore" stations (AL, S, W, and 00) were at the corners of a 16-station square, 6,000 feet to the side, having its center at the outfall terminus. Our three other sites (C-1, C-4, and C-5) were "control" stations 18,000 feet from the outfall terminus. We also occupied stations at the outfall terminus, near the mid-point of the outfall pipe, and on an artificial fishing reef approximately 1 mile west of the outfall terminus.

METHODS

To make the results of our surveys quantitatively meaningful and ecologically acceptable, we modified conventional principles of terrestrial quadrat-transect sampling for use underwater.

Field work was conducted during 3 days, 19 and 20 January, and 1 February, 1965, from the Department's 20-foot diving boat *Dolphin* after it was positioned near each sampling station by the Orange County Sanitation District's boat *Enchanter IV* skippered by Fred Munson.

Our actual sampling site was the spot where our anchor "set" in the bottom. We defined each study area by attaching a measured line to the anchor and traversing a circle with this line as its radius. Quantitative observations were made within the perimeter, while outside its boundaries only more-obvious bottom topography or biological features were noted. The bottom area covered was not the same for each station, since the effectiveness of observation depends wholly upon water clarity; the lower the visibility the more restricted the amount of bottom that can be surveyed using these techniques. At most stations, we could use a 3.1-meter line (about 10 feet) and thus enscribe a 30-square-meter area (about 270 square feet). On one occasion (Station S), bottom visibility was less than 3 meters, and we had to use a 2.2-meter line (about 8 feet) which encompassed 15 square meters of the bottom area (about 135 square feet). At two other stations (W and C-5) visibility was zero and we were unable to describe the study area; all sampling and physical observations were made by "feel." We employed the measuring line and anchor technique at all stations except two: the artificial reef (where we examined one pile of rock approximately 80 feet in diameter), and the mid-point on the outfall pipe. At these two stations, only the obvious faunistic assemblages were noted and recorded.

At each station, we determined the general conditions of the ocean floor (sediment composition and structure), and carefully noted ripple marks: (i) presence or absence, (ii) height (vertical distance from trough to crest), (iii) period (distance between peaks), (iv) direction, and (v) position of loose debris (whether on the peaks, the slopes, or in the troughs).

A diver-held plastic coring tube was utilized in sand-bottom areas to obtain a vertical profile of the sediments. Location of these cores is designated on each station sheet as "C." Cores were measured, the general uniformity and consistency of the sediments recorded, and the

presence of putrefaction below the sediment surface (evidenced by the odor of hydrogen sulfide) was noted.

Water depth was measured at the anchor, using a standard (oil-filled) diver's depth gauge, calibrated in 5-foot increments, accurate to 3 feet. Water depths were not interpolated to mean lower low water (MLLW).

Water temperatures were recorded in degrees C at the surface and the bottom, and at 10-foot increments above the bottom; these were taken with a diver-held thermometer calibrated in tenths of a degree.

Diver estimates of water clarity (the horizontal distance objects were visible) were made throughout the water column at 10-foot depth increments to describe the general conditions under which our more detailed biological observations were made (Figures 2, 3, 4, 5, 6, and 7). During previous studies (Turner et al. 1964, 1965, MS.) we determined that these estimates are approximately one-half the distance recorded when a horizontal reading is made with a Secchi disc. These horizontal readings describe the transparency of the water masses within the entire water column better than the usual vertical readings taken from the surface.

Substrate samples were collected within the station areas to determine diversity and abundance of polychaetes and foraminifera. Polychaete samples, designated by the letter "P" on station diagrams, consisted of approximately 1-pint of sediments skimmed from the top 1 to 2 inches of bottom. These were collected in wide-mouth quart jars and preserved in 10% formalin. Donald J. Reish, California State College, Long Beach, examined these samples. Foraminifera samples, designated by the letter "F" on station diagrams, consisting of about 2 ounces of sediment, were collected in 1-pint wide-mouth jars, and preserved immediately in a solution of rose bengal. James Ingle, Allan Hancock Foundation, University of Southern California examined these.

Observations were recorded underwater on plastic slates and later transcribed into laboratory logs, from which this report was written. Each plastic slate had a "study area" circle inscribed upon it to enable the divers to record accurately the position of the macroscopic animals and plants at each station (Figures 2, 3, 4, 5, and 6). We use "macroscopic" to define plants and animals which were visible to the divers and "microscopic" for organisms living in and on the substrate which were too small to be readily seen with the unaided eye.

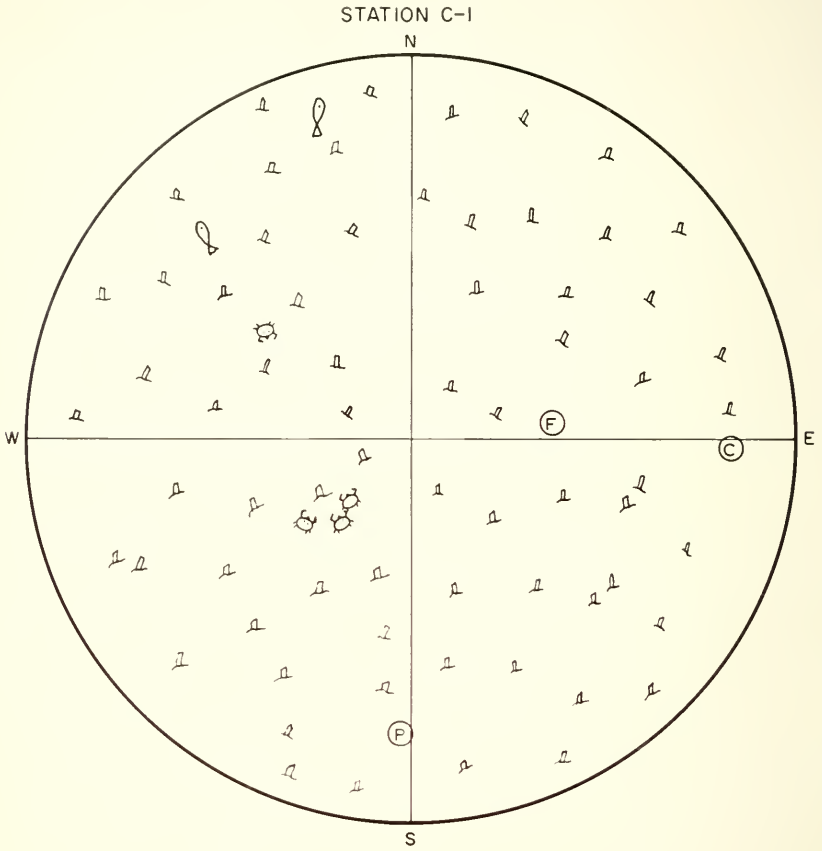
RESULTS—PHYSICAL

The physical features of the bottom are indicative of oceanographic conditions typical to the area. For example, an irregular bottom displaying no ripple marks indicates an area not disturbed by normal wave action; mixing or stirring is minimal. Conversely, distinct ripple marks with little or no detrital build-up on the bottom indicates an active water area; mixing and stirring prevail.

At Station C-4 (90 feet) the presence of worm castings and several living gorgonians indicated the sediments were relatively stable, a normal condition for this depth and general area.

The other sand-bottom stations were influenced by normal wave action, with no perceptible build-up of detrital material except at the outfall terminus.

At the outfall terminus, the bottom was scoured because of the velocity of the effluent flowing from the pipe. Abundant detrital material, both inorganic and organic, was evident in these depressions.



LEGEND (FIGURES 2 THROUGH 6)

- (C) core
- (F) foram sample
- (P) polychaete sample
- Diopatra ornata
- Heterocrypta occidentalis
- (A) Astropecten californica
- (L) Luidia foliolata
- gorgonian unid.
- Citharichthys stigmaeus

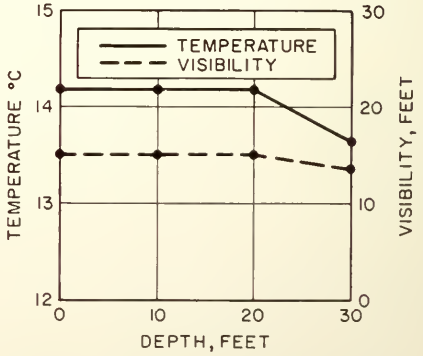


FIGURE 2. A pictorial representation of the study area, Station C-1 (approximately 270 square feet of bottom area), and its temperature-visibility profile.

Considerable particulate matter had remained in suspension, due to the swirling water currents, although the outfall was shut off for our inspection. We did not observe any sludge layer but small, oily globules were common and readily adhered to our diving suits and equipment.

The core samples we took at each station, except the artificial reef and the mid-section of the pipe, varied in length from 5 to 12 inches. Hydrogen sulfide (H_2S) was detected in all but two (Stations C-5 and C-4). The heaviest odor of H_2S was in the cores taken at the pipe terminus (Appendix 1).

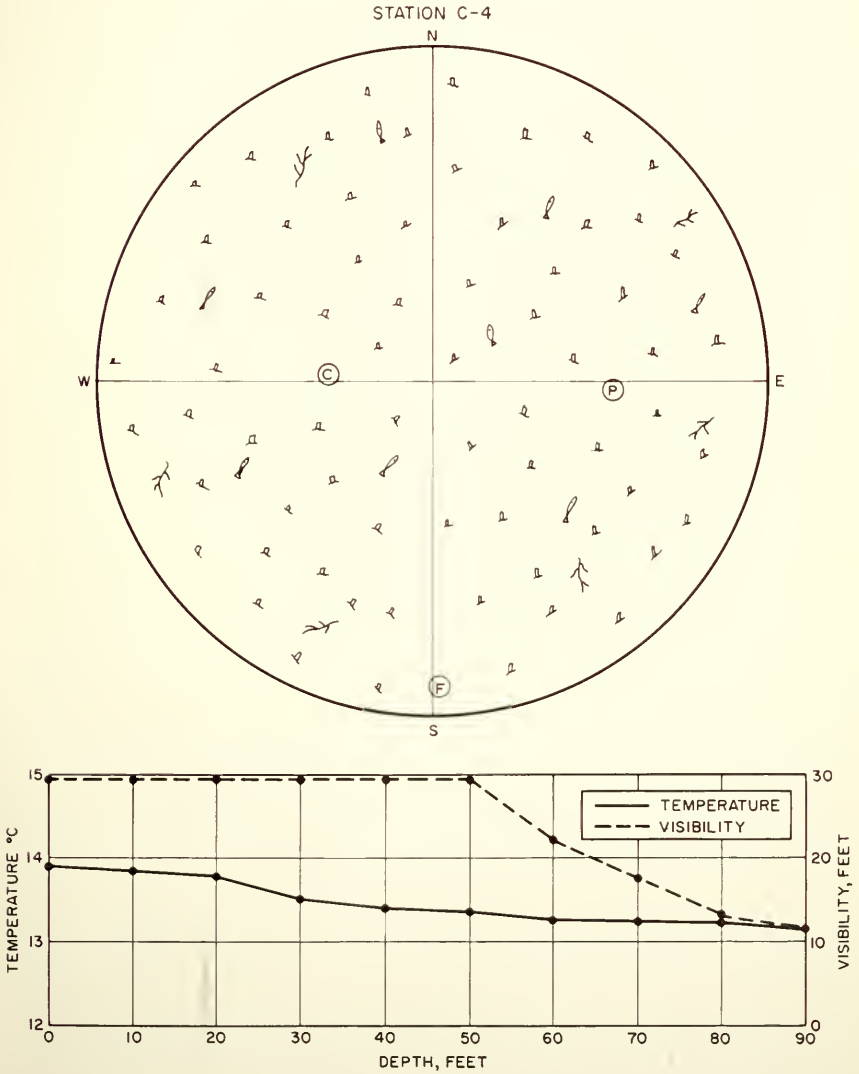


FIGURE 3. A pictorial representation of the study area, Station C-4 (approximately 270 square feet of bottom area), and its temperature-visibility profile. Legend with Figure 2.

RESULTS—BIOLOGICAL

Neither the polychaete nor foraminiferan samples (Appendices 2 and 3) were originally intended for inclusion in this report, but since they were graciously identified for us and because these organisms are important elements in the overall biota, we have included a quantitative list which may be significant in future surveys.

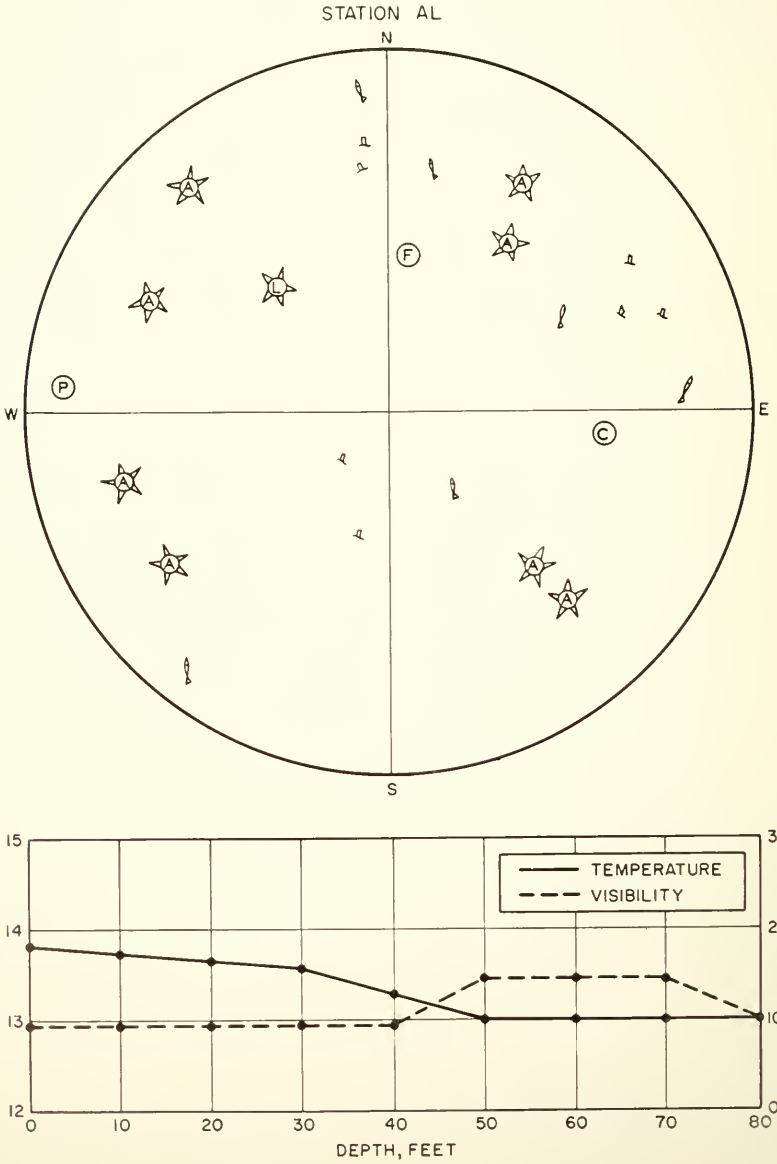


FIGURE 4. A pictorial representation of the study area, Station AL (approximately 270 square feet of bottom area), and its temperature-visibility profile. Legend with Figure 2.

At none of the sand-bottom stations, excluding those where visibilities did not permit observations, did the macroscopic animal assemblages appear to differ radically from assemblages in nonpolluted similar areas along the southern California shelf. Tube worms (*Diopatra ornata*), sand stars *Astropecten californica*, and the ubiquitous speckled sanddab, *Citharichthys stigmaeus*, are especially characteristic forms which exhibited normal abundance levels.

The Outfall Pipe

On 20 January 1965, it was arranged for us to dive on the outfall pipe terminus, with the effluent flow shut down for 30 minutes. Despite the shut down, poor water clarity and an overcast sky hampered our observations, and we limited the survey to the terminal 100 feet of the pipe, including the "vented" section. In two semi-circular areas adjacent to the pipe terminus, cores and sediment samples were collected.

Final 10 feet and pipe terminus

Most of the pipe was exposed, but there was some low riprap directly in front of it and along the sides. Much of the pipe was bare of growth but there was an unconsolidated layer of sediment on its surface. Some scattered colonies of the colonial anemone *Corynactis californica* were seen on the pipe sides, and several large areas were covered by colonies of a low-growing phoronid worm. Only a few barnacles were seen (*Balanus concavus pacificus* and *B. tintinnabulum*) and most of these were dead. On the sides were some small colonies of the polychaete worm *Dodecaceria fewkesi*, some tubes of the worm-like mollusk *Serpulorbis squamigerus*, and a few isolated patches of the small tan anemone *Metridium exilis*.

On the riprap near the end of the pipe we saw one, half-dead gorgonian *Muricea fruticosa*, a few bleached-out webbed stars, *Patiria miniata*, and the sea star *Pisaster giganteus*.

Terminus minus 10 to 60 feet

A few scattered small colonies of *Corynactis californica*, some acorn barnacles, and a few rock scallops, *Hinnites multirugosus* were encrusting the sides of the exposed pipe.

Terminus minus 80 feet

Several oval (6- by 4-inch) colonies of the low-growing orange stony coral *Astrangia lajollaensis* were seen.

Terminus minus 86 feet

The gorgonians, *Lophogorgia chilensis* and *Muricea fruticosa*, became more prominent but were still not abundant.

Terminus minus 100 feet

Large riprap and shoring covers the pipe, and there was a marked increase in the population of gorgonians, worms, etc. This area resembles the mid-section (40-foot depth) which was briefly surveyed on 1 February 1965.

The organisms attached at the pipe terminus and back at least 20 feet, were abundant numerically (forming large colonies or groupings) but exhibited markedly little diversity. This is a well-known, and classic

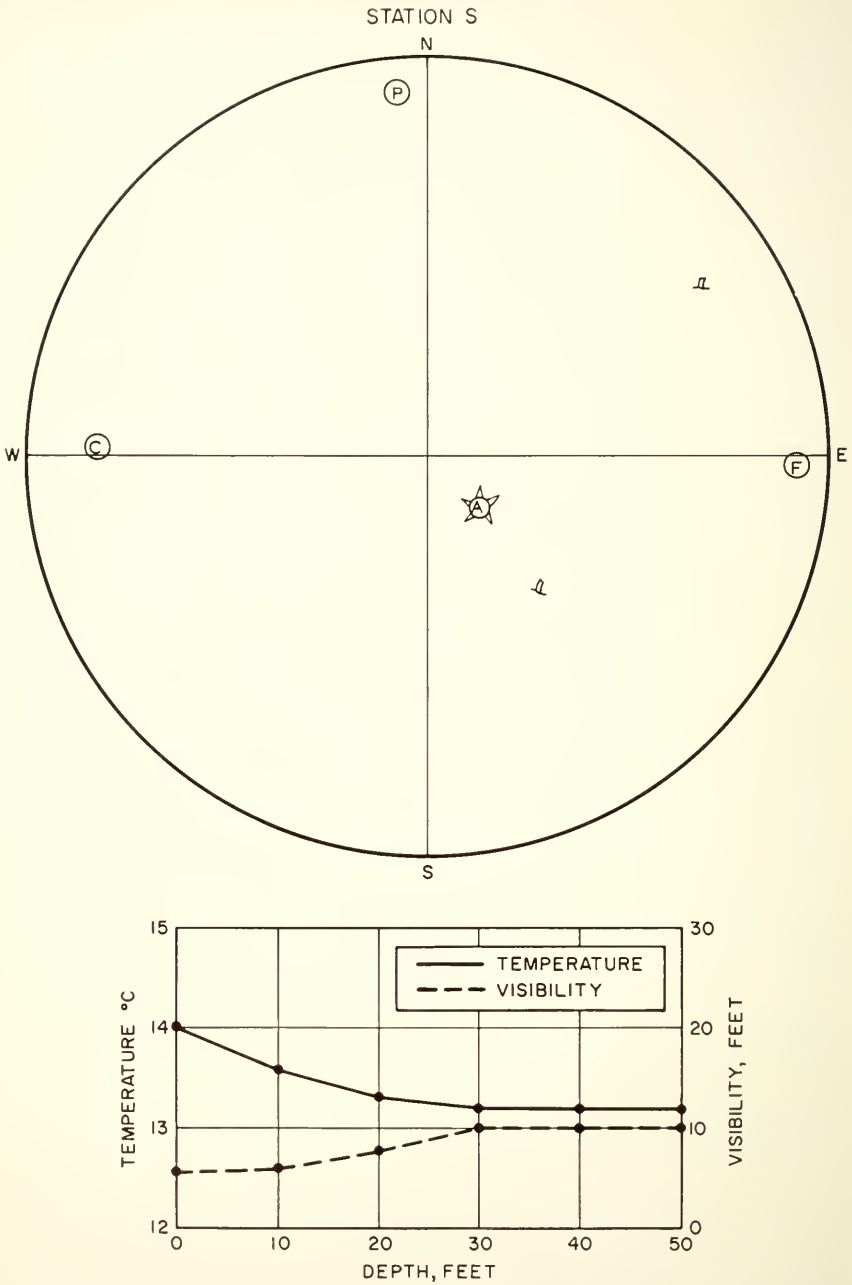
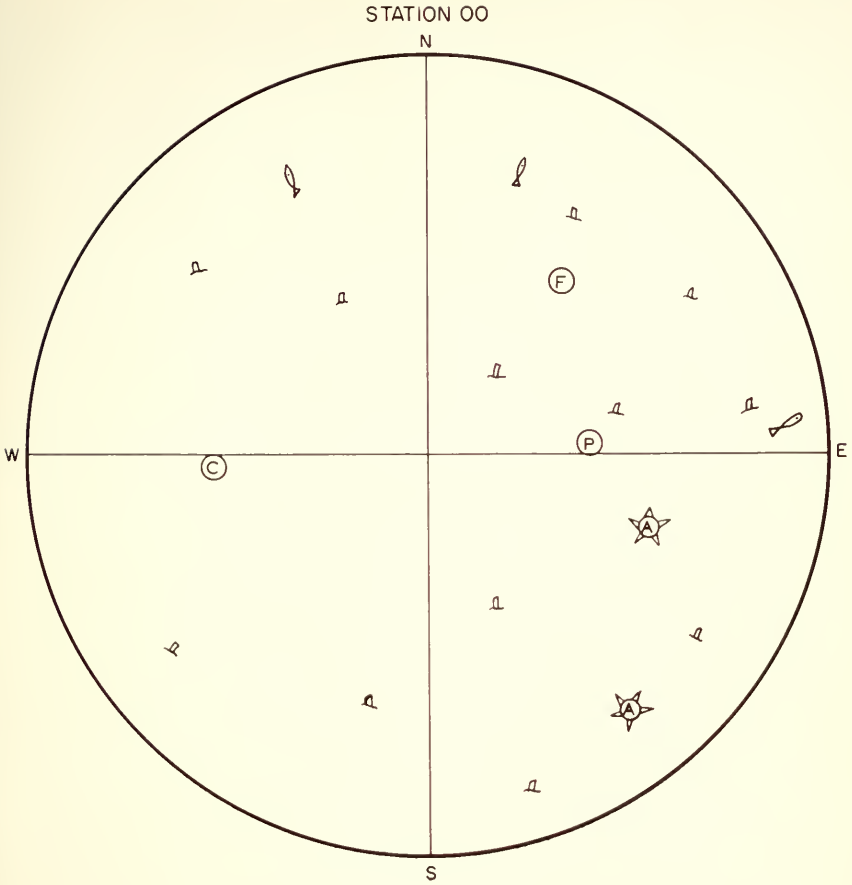


FIGURE 5. A pictarial representotion of the study orea, Station S (approximately 135 square feet of bottom area), and its temperature-visibility profile. Legend with Figure 2.



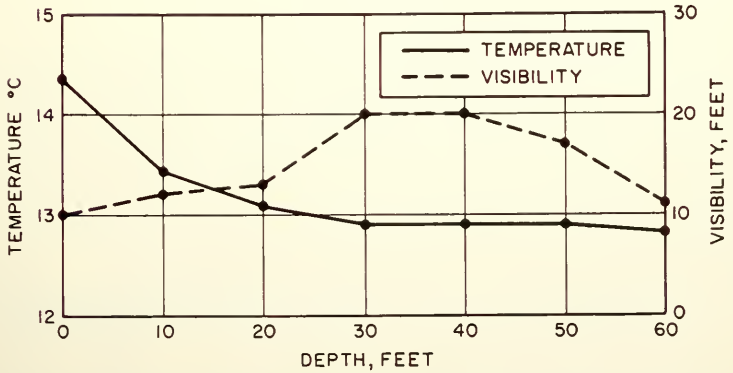
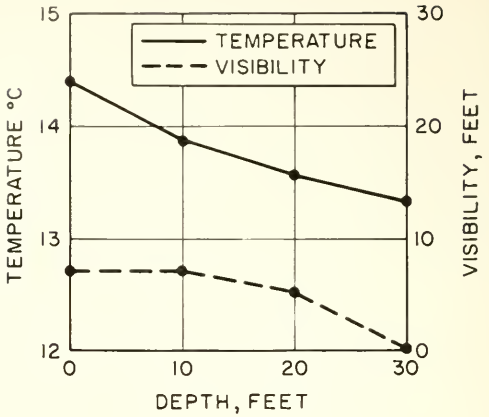
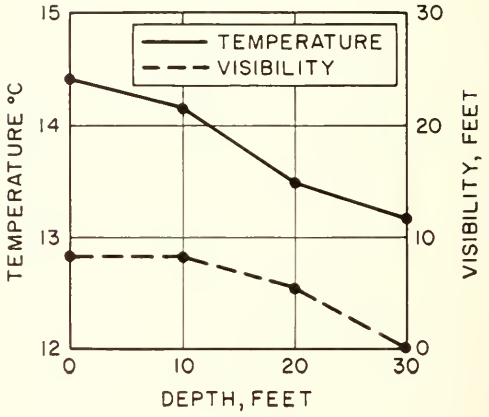


FIGURE 6. A pictorial representotion of the study area, Station 00 (aprpoximately 270 square feet of bottom area), and its temperoture-visibility profile. Legend with Figure 2.

STATION W



STATION C-5



END OF PIPE

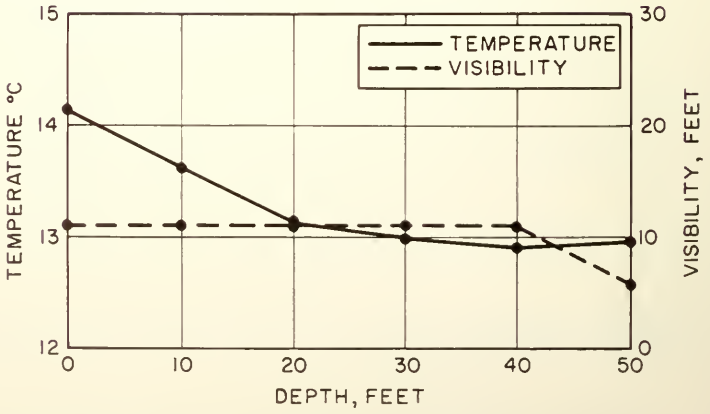


FIGURE 7. Temperature-visibility profiles for Station W, C-5, and the outfall terminus.

situation for an unhealthy environment, the few animals tolerating such extreme conditions form large colonies because of reduced competition from other species. The stony corals and gorgonians that populate the mid-section and within 100 feet of the pipe terminus appear, at least macroscopically, to be the normal fauna found on rocky bottoms, at these depths, along the southern California coast.

Most of the fishes (Appendix 4) associated with the pipe were concentrated at the terminus, where they formed loose schools or aggregations between the bottom and 20 feet below the surface, apparently feeding on the effluent itself. They appeared healthy, outwardly, and many of the kelp bass (*Paralabrax clathratus*) and sand bass (*P. nebulifer*) were relatively large. A brown rockfish (*Sebastodes auricu-*

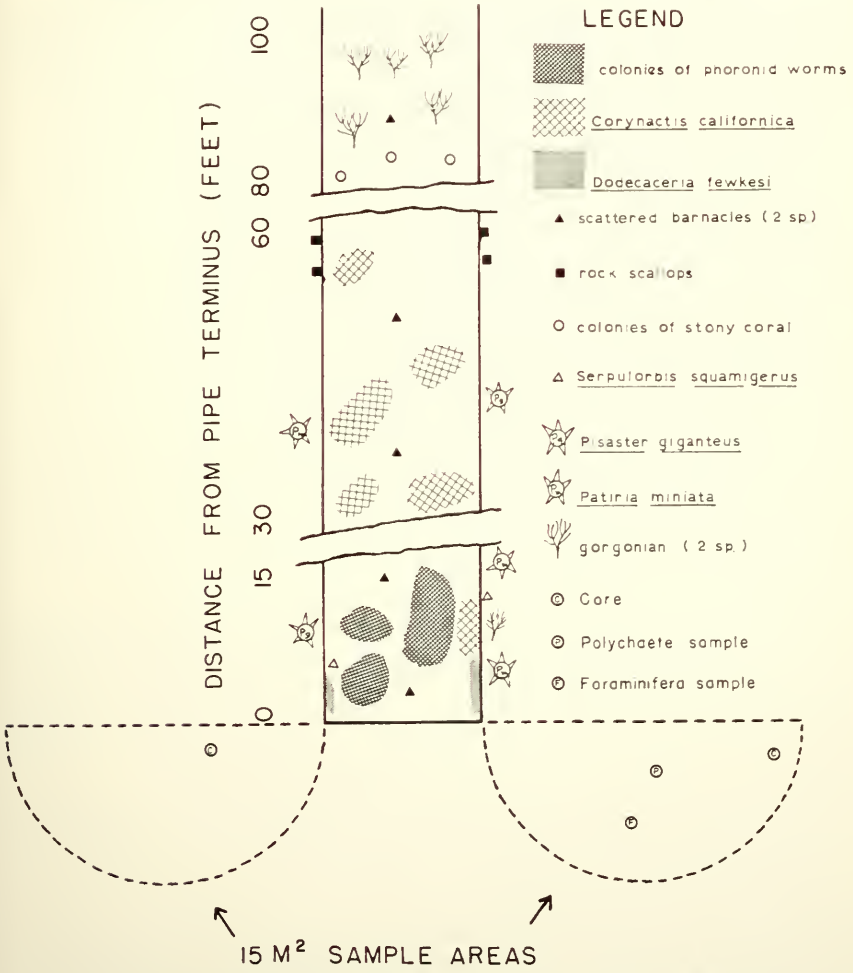


FIGURE 8. A pictorial representation of the major faunistic assemblages along the last 100 feet of the outfall pipe. No "macroscopic" animals or plants were recorded in the 2 sample areas (each encompassing approximately 135 square feet of bottom area) at the pipe terminus.

latus) was estimated to be 17 inches long, close to the maximum size for this species.

Inshore from the pipe terminus, the fishes oriented closer to the pipe and were notably reduced in both sizes and numbers. An exception, the bluespot goby (*Coryphopterus nicholsi*), appeared evenly distributed along the pipeline.

Huntington Beach Artificial Reef

On 1 February 1965 we made a survey dive on the artificial fishing reef approximately 1 mile west of the outfall terminus. This reef, one of four constructed in this area to increase the sportfisherman's success, is composed of 1,000 tons of quarry rock. It was built in December 1963 on flat sand bottom at a depth of 65 feet.

We surveyed approximately one-tenth of the total reef area (about 5,000 square feet), concentrating our attention on organisms attached to the rock. We hoped to compare these with growths on the outfall pipe to illustrate differences (if any) attributable to the effluent. We were unable to make a direct comparison because of the relative newness of the reef and, to a lesser extent, differences in depth.

Poor visibility (4 to 6 feet) was encountered so our fish population estimate was low (Appendix 4). On previous surveys large numbers of sand bass, a sought-after sport species, were common.

On 1 February 1965 the reef supported a moderate invertebrate fauna composed of barnacles, bryozoans, hydroids, crabs, and starfish. Although the species were typical for reefs of this age (12 to 18 months) and depth (65 feet), some expected species (tunicates and molluscs) were notably absent. In general, the biota of this reef resembled that observed at a similar artificial reef off the City of Santa Monica, in 60 feet of water, when it was the same age (Turner et al. MS.). The Santa Monica reef is influenced by eddy currents, and turbid waters and is indirectly subjected to effluent from the Hyperion outfall, several miles away. This Huntington Beach reef is directly influenced by the effluent field (Appendix 1), which probably accounts for the restricted speciation.

SUMMARY AND CONCLUSION

Field work was conducted on 19 and 20 January and 1 February 1965. Ten stations on the ocean floor were occupied, including the pipe terminus, a mid-section along the pipe, and an artificial reef. Bottom types encountered during the study were medium to fine silty sand, rock (the artificial reef and riprap around the pipe), and the outfall pipe.

Bottom water visibilities varied from 0 (Station W and C-5) to 12 to 15 feet (Station C-1). Surface visibilities ranged from 4 to 6 feet (artificial reef) to 30 (Station C-4).

Water temperatures ranged from 13.3°C to 14.4°C at the surface and 12.5°C to 13.7°C on the bottom.

The animal assemblages observed at each station appeared typical for these depths and bottom types, with two exceptions: (i) the number of species encrusting the last 100 feet of the outfall pipe was limited compared to the central section, and (ii) species diversity and numbers on

the artificial reef were considerably less than observed on artificial reefs in Santa Monica Bay which had been submerged for similar periods at similar depths.

Periodic diving surveys should be made at eight of these locations, at least semi-annually, to define the full effects of the effluent. We do not recommend additional diving surveys at Stations W and C-5, because the turbidity normal to these stations precludes a meaningful visual survey.

ACKNOWLEDGMENTS

This report was made possible with the help of several persons and organizations outside the Department of Fish and Game. We wish to thank Fred Munson for assisting us in locating the various sampling stations; Ted Dunn for coordination work during field surveys; and the Orange County Harbor Department for furnishing berthing facilities for our diving boat *Dolphin*.

We greatly appreciate the assistance of Donald J. Reish (polychaete identifications) and James Ingle (foraminifera identifications).

Within our own Department we are particularly indebted to John L. Baxter and John E. Fitch for editing this report, and the secretarial staff for typing it.

Although the cost of this work was reimbursed, much of the equipment we used had been purchased in part with Federal Aid to Fish Restoration Funds.

REFERENCES

Turner, Charles H., Earl E. Ebert, and Robert R. Given. 1964. An ecological survey of a marine environment prior to installation of a submarine outfall. Calif. Fish and Game, 50(3) : 176–188.

———1965. Survey of the marine environment offshore of San Elijo Lagoon, San Diego County. Calif. Fish and Game, 51 (2) : 81–112.

———nd. Artificial reef ecology. Calif. Fish and Game, Marine Resources Operations, manuscript.

APPENDIX 1

Physical Data for Stations Occupied During a Survey of the Marine Environment in the Vicinity of the Orange County Outfall (January and February 1965)

Station	Date	Depth (feet)	Temperature		Visibility (feet)		Bottom description	Remarks
			Surface	Bottom	Surface	Bottom		
W	1-19-65	30	14.4°C (57.9°F)	13.3°C (55.9°F)	7	1	Strongly oscillating; known only from core. Core: 6½ inches long; uniform, medium-fine, olive-green sand; slight H_2S in the bottom 2 inches.	Surface water yellow-green, grading with depth to yellow-brown. The bottom stirred.
C-5	1-19-65	30	14.4°C (57.9°F)	13.2°C (55.8°F)	8	zero	Heavily stirred; known only from the core. Core: 7 inches long; uniform, fine olive-green micaceous sand; no detectable H_2S.	Greenish surface water graded to yellowish-brown near the bottom. Bottom sediments could not be seen.
C-4	1-19-65	90	13.9°C (57.0°F)	13.2°C (55.8°F)	30	12	Irregular due to worm castings; no ripple marks; appears relatively stable and not often stirred by wave or current action. Core: 8 inches long; medium-fine, olive-green sand. No H_2S detected.	Bluish colored water; good bottom visibility; excellent observations in general station area.
AL	1-19-65	80	13.8°C (56.8°F)	12.9°C (55.2°F)	8 to 10	10	Flat; ripple marks low, irregular, 0.5 to 1 cm high (about $^3/_{16}$ to $^3/_8$ inches); 1 to 2 cm apart (about $^3/_8$ to $^3/_4$ inches) their crests aligned in an east-west direction; some debris on ripple slopes. Core: 5 inches long; uniform fine, gray, silty, micaceous sand; some H_2S along entire core length.	Blue-green surface water grading to bluish at 50 feet which continued to the bottom; good observational visibilities.
C-1	1-19-65	30	14.2°C (57.6°F)	13.7°C (56.7°F)	15	12 to 15	Medium-fine, olive-gray sand with extensive shelly debris and worm tubes. Ripple marks irregular, 2 to 3 cm high (about $^3/_4$ to 1¼ inches) and 8 to 10 cm apart (about 3⅛ to 4 inches); ripple crests aligned in an east-	Bluish-green water; good observational visibilities.

							west direction; only a slight oscillation of bottom sediments noted. Core: 7½ inches long; medium-fine olive-green micaceous sand; some H_2S in bottom 6 inches.	
00	1-20-65	60	14.3°C (57.7°F)	12.8°C (55.0°F)	10	10 to 12	Flat; ripple marks evenly-spaced 8 to 12 cm apart (about 3½ to 4½ inches) and 2 to 4 cm high (about ¾ to 1½ inches); aligned in north by east direction. Core: 12 inches long; uniform medium gray sand with slight H_2S odor for entire length.	Greenish-blue water at surface, becoming yellow-green to 25-foot depths where a distinct layering was present; below 25 feet the water was bluish-green to the bottom. Fair to good bottom visibility for observing.
8	1-19-65	50	11.0°C (57.2°F)	13.2°C (55.8°F)	5 to 6	10	Flat; ripple marks 4 to 7 cm apart (about 1½ to 2¾ inches) and 1 to 2 cm high (about ⅜ to ¾ inches); ripples aligned in an east-west direction. Core: 8 inches high; uniform fine olive-green sand; slight H_2S odor throughout.	Greenish-blue surface water turning to yellowish-green at 20 feet where a distinct layer was noted; bluish-green below this to the bottom. Fair observing visibility.
Outfall terminus	1-20-65	50	14.1°C (57.4°F)	13.0°C (55.4°F)	10 to 12	4 to 8	Description of two cores: Core east of the pipe terminus: 12 inches long; top 5 inches dark gray-black medium sand; heavy H_2S odor; the bottom 7 inches uniform gray, medium sand; some H_2S. Core west of the pipe terminus; 9 inches long; top 2 inches dark gray-black medium sand; heavy H_2S odor; bottom 7 inches uniform dark gray medium sand; some H_2S.	Water fairly clear but dark because of overcast skies; a minor surge on the bottom caused slight oscillations of the lighter bottom debris.
Huntington Beach artificial reef	2-1-65	65	13.3°C (55.9°F)	12.5°C (54.5°F)	10 to 12	4 to 6	Quarry rock on gray silty sand; placed in four 80- to 100-foot diameter piles, each pile 75 to 100 feet from its nearest neighbor.	The sewage field moved offshore and over the reef as the tide changed. A murky oil layer was evident from the surface to a 40-foot depth. Below this, the turbidity appeared to be caused by suspended bottom sediments.
Mid-section of the pipe	2-1-65	40	---	---	8 to 10	1 to 3	Rock riprap covering the outfall pipe.	Murky bottom conditions; suspended matter precluding an adequate survey.

APPENDIX 2

Polychaete Worms and Other Invertebrates Recorded from a 1-Pint Sample of Bottom Sediment Taken at Various Stations Around the Orange County Outfall January 19 and 20, 1965 *

Species	Station							
	C-1	C-4	C-5	S	AL	W	00	Outfall terminus
POLYCHAETA								
Cirratulidae								
Chaetozone sp.	+		+	+	+	+		
Cirriformia sp.							+	+
Tharyx sp.				+			+	
Dorvilleidae								
Dorvillea sp.								+
Glyceridae								
Glycera sp.	+							
Goniadidae								
Glycinde sp.					+	+	+	
Hesionidae								
Ophiodromus sp.							+	+
Lumbrineridae								
Lumbrineris sp.				+				
lumbrinerid		+					+	
Maldanidae								
maldanid		+			+			
Nephtyidae								
Nephtys sp.	+	+	+	+	+		+	
Nereidae								
Platynereis sp.		+						
Opheliidae								
Armandia sp.								+
Orbiniidae								
Haploscoloplos sp.	+		+			+		
Paraonidae								
paraonid		+						
Phyllodocidae								
phyllodocid	+	+			+	+	+	+
Sabellidae								
Chone sp.		+						
Euchone sp. (near limnicola)				+				
Sphaerodoridae								
sphaerodorid					+			
Spionidae								
Prionospio pinnata						+		+
Prionospio sp.		+	+	+	+		+	
Syllidae								
syllid		+						
Terebellidae								
Amaeana occidentalis	+			+		+		
AMPHIPODA (gammaridea)	+	+	+	+			+	+
CUMACEA	+		+					+
NEMERTINA	+							
POLYCLADIDA				+				
ISOPODA							+	
PYCNOGONIDA	+		+			+		
ECHINOIDEA (tiny urchin, unidentified)	+							

* The total number of specimens in each sample ranged from 50 to 75.

APPENDIX 3

Foraminifera Collected at Various Stations Around the Orange County Outfall
January 19 and 20, 1965

Species	Outfall terminus		Station													
			C-1		C-1		C-5		S		AL		W		09	
	L*	D†	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Planktonic Species—Total percent		**100.0**		**100.0**		**100.1**		**99.9**		**100.0**		**99.7**		**99.9**		**100.0**
Globigerina bulloides bulloides		52		53.8		79.2		30.1		60.0		83.3		41.2		80.0
Globigerina quinqueloba quinqueloba		48		46.2		16.7		65.2		20.0		8.3		53.8		20.0
Globigerinoides rubra								1.3				8.3				
Globigerinoides uvula										20.0				1.9		
Orbulina universa						1.2										
Benthic Species—Total percent	**100.0**	**99.8**	**99.8**	**100.2**	**99.7**	**99.9**	**99.3**	**100.2**	**101.2**	**99.9**	**99.9**	**99.5**	**99.9**	**100.3**	**100.0**	**100.1**
Benthic Hyaline Species—Total percent	**60.9**	**56.5**	**90.0**	**72.0**	**64.7**	**25.7**	**96.8**	**85.3**	**58.8**	**79.2**	**89.9**	**41.2**	**95.3**	**91.7**	**80.8**	**54.3**
Bolivina decussata								1.0				0.2		0.2		
Bolivina pacifica					5.0	2.0					0.5	0.4	0.9			
Bolivina vaughani	8.7				26.8	0.4	3.2	1.0	5.1		2.6	2.6	3.4	0.2	1.8	
Buccella frigida		3.6	4.2	3.6	2.1	0.8		1.0		0.4		1.8		0.6		
Bulimina marginata denudata					1.0							1.5	0.3	0.5		0.4
Buliminella elegantissima	21.7	16.3	15.5	18.6	24.7	11.7	91.7	64.1	43.3	74.1	76.2	21.9	76.2	82.3	63.2	39.7
Cassidulina minuta						0.4				0.4			0.3			
Cibicidea fletcheri		2.0		0.6										0.2		
Cornuspira spp.	2.2	0.5														
Discorbis columbiensis	21.7	11.7	5.6	22.8		2.0		1.8						2.4		1.3
Elphidium incertum		1.1		7.8		1.2		8.6	1.1	2.6		2.4		2.1		3.0
Elphidium spinatum		3.6	5.6	2.4					1.1	0.6	1.6	0.4	1.5	0.5		1.3
Elphidium translucens		1.6	42.3	11.4		1.2	1.3	2.4	1.7	0.2	3.2	3.5	11.8	1.6	1.0	2.6
Elphidium tumidum		0.5	7.0	1.2		0.8		1.4				0.7		0.2		0.4
Elphidium spp.	2.2	1.0	7.0	1.2											1.6	
Epistominella bradyana											0.5	0.2				
Hopkinsina pacifica	2.2				2.1	1.2			0.6		0.5	0.4				
Lagena amphora									0.6			0.2	0.3		1.6	
Lagena perlucida	2.2	1.5	2.8		1.0				1.7		1.1		0.3	0.3	1.0	2.6
Nonionella miocenica stella		2.0			1.0	1.2					0.5	1.5		0.3		0.4
Nonionella scapha basispinata		5.1		2.4	1.0	2.0	0.6	1.0	2.8	0.6	3.2	3.7	0.6	0.3	1.6	2.2
Polymorphina charlottensis						0.8										0.4

APPENDIX 3—Continued

Foraminifera Collected at Various Staitons Around the Orange County Outfall
January 19 and 20, 1965

Species	Outfall terminus		Station													
			C-1		C-1		C-5		S		AL		W		00	
	L*	D†	L	D	L	D	L	D	L	D	L	D	L	D	L	D
Benthic Porcelaneous Species—Total percent	**4.3**	**4.6**	**2.8**	**17.4**		**0.4**		**2.0**	**2.2**	**1.9**	**0.5**	**1.3**		**2.9**		**0.9**
Quinqueloculina akneriana				1.2				1.0		0.2		0.4		0.3		
Quinqueloculina costata				9.0						0.2				0.8		
Quinqueloculina spp.	1.3	2.6	2.8	2.1		0.4			1.1	1.1	0.5	0.7		0.8		0.9
Triloculina spp.		0.5		0.6				1.0	1.1	0.2		0.2		0.2		
Triloculina trigonula		1.5		4.2						0.2				0.8		
Benthic Arenaceous Species—Total percent	**34.8**	**38.7**	**7.0**	**10.8**	**35.0**	**73.8**	**2.5**	**12.9**	**40.0**	**18.8**	**9.5**	**57.0**	**4.6**	**5.7**	**19.2**	**44.9**
Cribrostomoides columbiensis columbiensis		1.5				0.8				0.2		2.8		0.2		0.9
Cribrostomoides columbiensis robustum		6.1		1.8		1.2		1.1	1.7	5.1	1.1	5.9		0.3	1.6	9.5
Eggerella advena		4.1	1.4	0.6	6.2	10.1	1.3	6.2	34.3	7.9	7.1	32.4	1.5	1.4	5.6	7.8
Goesella flinti												0.2				
Haplophragmoides advenum		1.0														0.1
Reophax communis	2.2	0.5		1.2		3.6	0.6	2.9		1.1		1.3		0.6		1.3
Reophax scotti												0.2		0.2		
Saccammina atlantica					27.8	31.9			0.6	0.6		5.3				
Textularia earlandi						0.8					0.5	0.4	0.6			
Trochammina inflata		2.0				0.8				0.9						5.6
Trochammina pacifica	32.6	23.0	5.6	6.6	1.0	24.2	0.6	2.4	3.4	3.0	0.5	8.5	2.5	2.8	12.0	19.0
Trochammina squamiformis		0.5		0.6		0.4								0.2		0.4
Total number of specimens/gram (foraminiferal number)‡		0.9		2.1		11.7		16.2		72.2		42.8		44.2		15.7
Total number of specimens		267		252		369		390		652		658		1,008		367
Total number of live benthic specimens/gram‡		0.2		0.6		3.1		6.6		19.7		12.3		14.1		5.3

* L = Percent live funa
† D = percent dead fauna
‡ per gram of dry sediment

APPENDIX 4

Relative Abundance of Fishes Recorded in the Vicinity of the Orange County Outfall January and February 1965

Station		C-1	C-4	C-5*	S	AL	W*	00	Outfall terminous	Artificial reef†
Approx. area surveyed		270 sq. ft.	270 sq. ft.		135 sq. ft.	270 sq. ft.		270 sq. ft	270 sq. ft.	5,000 sq. ft.
Common name	Scientific name	Number per station (size in inches)								
C-O turbot	*Pleuronichthys coenosus*								1 (9)	
Speckled sanddab	*Citharichthys stigmaeus*	2 (5)	8 (3-4)			6 (4-5)		3 (5)	25 (5-6)	
Kelp bass	*Paralabrax clathratus*								50 (6-18)	
Sand bass	*Paralabrax nebulifer*								75 (11-18)	50 (10-17)
Black perch	*Embiotica jacksoni*								60 (6-10)	50 (5-9)
Pile perch	*Rhacochilus vacca*								75 (5-9)	75 (5-8)
Rainbow seaperch	*Hypsurus caryi*								15 (9-12)	
Rubberlip perch	*Rhacochilus toxotes*								15 (6-8)	25 (5-8)
White sea perch	*Phanerodon furcatus*								50 (5-7)	100 (5-7)
Blacksmith	*Chromis punctipinnis*								100 (6-9)	100 (2-9)
Senorita	*Oxyjulis californica*								10 (8-9)	
Bluespot goby	*Coryphopterus nicholsi*								25 (2-5)	50 (2-4)
Black-and-yellow rockfish	*Sebastodes chrysomelas*								1 (12)	
Brown rockfish	*Sebastodes auriculatus*								3 (12-17)	1 (10)
Sculpin	*Scorpaena guttata*								3 (8-10)	2 (7-8)
Painted greenling	*Oxylebius pictus*								1 (6)	
Cabezon	*Scorpaenichthys marmoratus*								1 (11)	
Topsmelt‡	*Atherinops affinis*	20 (6-8)								

* Zero visibility
† Impaired visibility
‡ Near surface—above station

APPENDIX 5

The "Macroscopic" Invertebrates Recorded During a Survey in the Vicinity of the Orange County Outfall, January and February 1965

Phylum	Scientific name	Common name	Area observed
Porifera (sponges)	*Sycon* sp.	sponge	R*
Cnidaria	*Corynactis californica*	aggregate anemone	P†
(anemones, gorgonians, etc.)	*Metridium exilis*	solitary anemone	P
	Astrangia lajollaensis	aggregate coral	P
	Muricea fruticosa	gorgonian	P
	Lophogorgia chilensis	gorgonian	P
		gorgonian, unid.; cream colored	S‡
		hydroids, unid.	R
Annelida	*Dodecaceria fewkesi*	cirratulid polychaete worm	P
(segmented worms)	*Diopatra ornata*	onuphid polychaete worm	S
Phoronida		phoronids, unid.	P
Bryozoa	*Scrupocellaria diegensis*	bryozoan	R
	Holoporella brunnea	encrusting bryozoan	R
	Bugula neritina	bryozoan	R
	Nolella sp.	encrusting bryozoan	R
Arthropoda	*Loxorhynchus grandis*	spider crab	RS
(crabs, barnacles, etc.)	*Cancer anthonyi*	cancer crab	R
	Heterocrypta occidentalis	elbow crab	S
	Balanus concavus pacificus	acorn barnacle	P
	Balanus tintinnabulum	acorn barnacle	P
	Scalpellum californica	goose neck barnacle	S§
Mollusca	*Megasurcula carpenterianus*	tower snail	S
(clams, snails, etc.)	*Serpularbis squamigerous*	tube-building snail	P
	Hinnites multirugosus	rock scallop	P
Echinodermata	*Astropecten californica*	sand star	S
(sea stars, sea urchins, etc.)	*Luidia foliolata*	sea star	S
	Patiria miniata	webbed star	P
	Pisaster brevispinus	sea star	R
	Pisaster giganteus	giant sea star	R
	Lytechinus anamesus	white sea urchin	S

* R = observed at the artificial reef
† P = observed at the outfall pipe
‡ S = observed at one or more of the sand stations
§ One observed in the general area near Station AL

Calif. Fish and Game, 52(1) : 49–53. 1966.

LENGTH FREQUENCIES OF PACIFIC HAKE *(MERLUCCIUS PRODUCTUS)* LANDED IN CALIFORNIA THROUGH 1964[1]

E. A. BEST[2] and R. J. NITSOS
Marine Resources Operations
California Department of Fish and Game

Although Pacific hake have never been the object of a commercial fishery, they have been landed and processed in California for animal food. Routine observation of these landings provided a source of biological information on Pacific hake. This paper summarizes size of fish, time of year, and locality of the fishery through 1964.

INTRODUCTION

Pacific hake have never been the object of a commercial fishery on the Pacific coast of the United States, but they have been caught incidentally by otter trawl vessels fishing for other demersal species. In general, hake have only been landed at times and places where they could be processed for animal food. There has been limited utilization for human consumption when more-desirable species were in short supply. Recently, small amounts of Pacific hake have been used as low-priced fillets for special markets.

Historically, the California otter trawl fishery has been for flounders. Regulations designed to protect the young of various flounders stipulate a minimum mesh size of not less than $4\frac{1}{2}$ inches (164 mm) inside the knots. This mesh size allows small hake, as well as small flounders, to escape, and at present only adult hake are caught to any degree by the trawl fishery. In addition, California law prohibits trawling within 3 miles of the mainland shore; this further protects the hake resource by providing a sanctuary from trawl nets.

METHODS

Most of our length-frequency measurements were made during an ecological survey of northern California trawling grounds. This work was designed to determine the distribution of species in time and space, but not to measure abundance. Additional measurements were obtained during routine sampling of animal-food landings. All available measurements have been combined by port of landing by month (Tables 1 to 4). These summaries reflect availability only, based upon the assumption that if more fish are available to the fishery more will be caught. Previous reports on the relative abundance of Pacific hake in animal-food landings, have not mentioned length frequencies (Best, 1959, 1961; Nitsos and Reed, 1965).

Fishing activities of the trawl fleet are controlled to a great extent by demands of commercial markets, and the hake we measured were

[1] Submitted for publication October 1965.
[2] Now with International Pacific Halibut Commission, Seattle, Washington.

caught incidental to other trawling operations. Juvenile hake seldom are retained by the nets used in these fisheries, so the frequencies presented here do not necessarily represent the actual sizes inhabiting the fishing grounds.

PORTS SAMPLED

Santa Barbara

A small otter trawl fishery has existed at Santa Barbara for many years. In 1960, the physical facilities were modernized and a plant was established for grinding fresh fish into animal food. Routine sampling of animal-food landings during 1961 and 1962 provided information on hake sizes, and indicated an estimated 152,000 pounds were landed in 1961, and 253,000 pounds in 1962.

Fishing generally has been within the confines of the Santa Barbara Channel at depths of 150 fathoms (274 m) or less. During the period December to March, small fish (20 to 35 cm TL) have been predominant. Adults apparently are spawning in areas beyond the continental shelf during this period, and are not available to the Santa Barbara trawl fishery. Juvenile hake must be present in large numbers for so many to become entrapped by the large-mesh otter trawls in use.

During the remainder of the year, adults (40 to 76 cm TL) became available to trawl nets, and they were harvested in greater numbers (Table 1).

TABLE 1

Length Frequencies of Hake Landed at Santa Barbara, by Month

Total length (cm)	Month												
	J	F	M	A	M	J	J	A	S	O	N	D	Totals
14–15											2		2
16–20											3		3
21–25	28	17	2				2				4	5	58
26–30	36	30	45				10		16		5	44	186
31–35	17	39	33		1	2	10	1	10	1	2	8	124
36–40	4	15	12		2	1	69	1	63		8	4	179
41–45	4	22	9	2	11	63	82	8	70	1	18		290
46–50	4	19	2	10	34	114	74	31	77	10	25	1	401
51–55	2	31	3	15	52	54	45	37	73	6	21	5	344
56–60	2	19	11	18	56	41	27	16	38	6	15	7	255
61–65	1	18	8	10	35	14	18	4	23	1	12	5	149
66–70	2	2	10	1	21	2	4	2	4	2	8	4	62
71–75	1		2		2		6		2				13
76–80		2	1										3
Totals	101	214	137	56	214	291	347	100	376	27	123	83	2,069

Morro Bay

Morro Bay has gradually become important as a trawl fishing port, but facilities for processing fish for animal food were not established until 1959. Best estimates of hake landings at Morro Bay from 1959 through 1962 are 21, 36, 73, and 44 thousand pounds respectively. Vessels operating from Morro Bay fish the open ocean from about Point Conception north to Point Piedras Blancas. In 1964, the maxi-

TABLE 2

Length Frequencies of Hake Landed at Morro Bay, by Month

Total length (cm)	Month												Totals
	J	F	M	A	M	J	J	A	S	O	N	D	
16–20											1		1
21–25		2			6	7		4	1	23	7	29	79
26–30		15	1		8	3		9		46	18	38	168
31–35		2	3		2	4	2	14		13	6	10	53
36–40		2	1		2	5	19	11	8	12	8	6	77
41–45		6				3	20	23	3	6	1	1	66
46–50	1	4	2	2	5	5	30	23	12	17	28	8	137
51–55	2	3	3	12	11	21	37	18	9	13	28	16	173
56–60	6	5	1	10	15	60	12	7	9	18	23	28	224
61–65	2	8	2	5	8	51	21	9	2	13	16	29	166
66–70	1	5			5	12	9	2	1	6	7	19	79
71–75		5	--			7	2			3	1	3	21
76–80		--	--							1			1
Totals	15	57	13	23	62	178	182	123	45	171	177	187	1,236

mum depth fished was about 200 fathoms (366 m), but most effort has been expended in 90 to 150 fathoms (164–274 m).

Juvenile fish (20 to 30 cm TL) have been present throughout the year, but were especially numerous from October to December. Adults (40 to 77 cm TL) have been abundant during June and July; have declined somewhat during August and September; and have become abundant again during October, November, and December (Table 2).

Monterey

Only minor quantities of hake have been landed at Monterey in recent years. No sampling has been done and no length frequencies are available. Fishing generally has been limited to the area between Point Sur and Pigeon Point at depths of 150 fathoms (164 m) or less. Heimann (1963) reported in detail on the trawl fishery of Monterey Bay.

San Francisco

Trawling activities began in the San Francisco area as early as 1876, and small amounts of hake have always been present in the catch. In fact, the original description of the species was based on a hake collected from a San Francisco market in 1855, 20 years prior to the beginning of a trawl fishery in the vicinity. Little information is available on the quantity of hake landed, but an estimated 250,000 pounds were taken in 1958.

San Francisco trawl vessels fish in open ocean waters off the central California coast from about Pigeon Point north to Point Arena. Some trawling is done as deep as 400 fathoms (732 m), but most is in less than 200 fathoms (366 m). There is great seasonal variation in the depths fished, depending upon the species being sought.

Few juvenile hake have been caught by otter trawling in this area. Adult hake (40 to 78 cm TL) have become available to the fishery about April, reached peak abundance during June and July, and then essentially disappeared from the fishery by December (Table 3).

TABLE 3

Length Frequencies of Hake Landed at San Francisco, by Month

Total length (cm)	Month												Totals
	J	F	M	A	M	J	J	A	S	O	N	D	
21–25					2	1				1	1		5
26–30	3			1			1						5
31–35	1		1		1		1	2	1		2		9
36–40				2	1	7	14	2					26
41–45				7	27	7	25	7	3		1		77
46–50	1			5	22	19	32	22	5		3		109
51–55			2	25	32	112	127	60	10	4	18		390
56–60	1		1	46	69	99	147	40	14	14	21		452
61–65			1	19	36	44	42	23	5	16	11	2	199
66–70	2			9	9	12	11	14	6	12	4		79
71–75						3	1	5	2	6	4		21
76–80								2	2	2	3		9
Totals	8	0	5	114	199	304	401	177	48	55	68	2	1,381

Fort Bragg

Hake landings at Fort Bragg totaled 74, 12, 9, and 43 thousand pounds in 1958 through 1961. A price dispute has stopped all landings for animal food since early 1962. No length measurements are available for this port.

Fishing has been limited to the open ocean between Point Arena and Cape Mendocino at depths up to 300 fathoms (549 m), although most effort is expended inside the 150-fathom (247 m) contour.

Eureka

Hake landings at Eureka have varied considerably, with largest landing (732,000 pounds) in 1959. A price dispute has stopped all animal-food landings since early 1962. Prior to then, fish were caught in open ocean waters between Cape Mendocino and Cape Blanco, Oregon. Fish-

TABLE 4

Length Frequencies of Hake Landed at Eureka, by Month

Total length (cm)	Month												Totals
	J	F	M	A	M	J	J	A	S	O	N	D	
16–20							4	5	2				11
21–25							5	7	1				13
26–30									1				1
31–35									3				3
36–40	1						1	8	4				14
41–45							14	40	26	3	1	4	88
46–50				1	1	2	10	20	19	9		3	65
51–55				6	2	4	31	52	52	42	11	8	208
56–60	1		1	5	19	5	28	82	30	55	27	3	256
61–65		1		3	12	3	15	46	14	55	12	3	164
66–70	1				5	1	1	17	5	39	1	3	73
71–75						1	1	4	3	11			20
76–80								3		1			4
81–85								1					1
Totals	3	1	1	15	39	16	110	285	160	215	52	24	921

ing has been carried out to depths of near 400 fathoms (732 m), but generally the effort has been expended inside of 200 fathoms (366 m).

Few small hake were taken in this area. Adult fish (40 to 81 cm TL) appeared in the April catch, reached a peak in August, and declined through December (Table 4).

DISCUSSION

Pacific hake are not the object of an established commercial fishery in California, but they are taken incidental to the otter trawl fishery, and are used to some extent as an ingredient of animal food. These incidental landings have provided an opportunity to measure the hake that are vulnerable to the California otter trawl fishery.

Small hake have been abundant only at the southernmost trawl fishing ports of Santa Barbara and Morro Bay. The fishing grounds utilized by otter trawl vessels from these ports are inshore from known hake spawning grounds (Comm. Fish. Rev., 1963). The relatively greater abundance of young hake here may be directly related to offshore spawning.

Adult fish, larger than 40 cm TL, were noted at all California ports during summer months. They were relatively scarce at all ports during January, February, and March. This absence is assumed to be associated with spawning activities which occur offshore beyond the reach of existing trawling operations. Upon completion of spawning, adults return to inshore areas over the continental shelf and become vulnerable to the trawl fishery. During the summer, hake apparently are present along the entire Pacific coast, at least as far north as British Columbia.

REFERENCES

Best, E. A. 1959. Status of the animal food fishery in northern California, 1956 and 1957. Calif. Fish and Game, 45 (1) : 5–18.

_____ 1961. The California animal food fishery, 1958–1960. Pac. Mar. Fish. Comm., Bull., (5) : 5–15.

_____ 1963. Contribution to the biology of the Pacific hake, *Merluccius productus* (Ayres). Rept. Calif. Coop. Oceanic Fish. Invest., (9) : 51–56.

Commercial Fisheries Review. 1963. Distribution and abundance of adult hake off southern California and northern Mexico studied. Com. Fish. Rev., 25 (6) : 38–40.

Heimann, Richard F. G. 1963. Trawling in the Monterey Bay area, with special reference to catch composition. Calif. Fish and Game, 49 (3) : 152–173.

Heimann, Richard F. G., and Daniel J. Miller. 1960. The Morro Bay otter trawl and party boat fisheries, August, 1957, to September, 1958. Calif. Fish and Game, 46 (3) : 35–58.

Nitsos, R. J., and Paul H. Reed. 1965. The animal food fishery in California, 1961–1962. Calif. Fish and Game, 51 (1) : 16–27.

NOTES

ADDITION OF *TILAPIA MOSSAMBICA* PETERS TO THE CALIFORNIA FAUNA

Some tilapia that I observed on January 3, 1964, in a 0.25-acre pond and its tributary 5 miles north of the Salton Sea, represent the first verified record of free-living tilapia in California.

The pond and tributary are on the eastern side of the Salton Sea, near the Hot Mineral Spa, Imperial County. Mosquitofish, *Gambusia affinis*, sailfin molly, *Poecilia latipinna*, and desert pupfish, *Cyprinodon macularius*, are also present in this tributary.

My field identification of tilapia from Lowe's (1955) key was confirmed by Chen Foo Yan, Tropical Fish Culture Research Institute, Malacca. He states (pers. commun.), "The fish are definitely *Tilapia mossambica* of Malayan (or Javanese) origin and probably originated from consignments from Singapore."

Humphrey Greenwood, Ethelwynn Trewavas, and Ro McConnell, British Museum (Natural History) Zoological Department; Carl L. Hubbs, Scripps Institution of Oceanography; and G. W. Prowse, Tropical Fish Culture Research Institute, Malacca, gave valuable assistance in the identification.

D. J. Sargent, owner of Del Rancho El Sargent, a tropical fish farm located directly below the pond, has cultured tilapia on his property. This may have been the source of these specimens.

Tilapia could become established in the Salton Sea, because temperature and salinity ranges there are within their physiological tolerance, and I held juvenile and adult tilapia in Salton Sea water for more than a month. Experimental work at Chino Fisheries Base also showed that some tilapia can survive temperatures of 42°F.; the Salton Sea reaches a minimum temperature of 50°F. (Carpelan, 1961). Hickling (1963) stated that tilapia can exist in salt water, but high salinities may inhibit breeding; however, Brock and Takata (1954) reported that tilapia spawned in sea water having a salinity of about 34.85‰; the Salton Sea averages about 35.0‰, and has substantial areas of lower salinity off the mouths of the New and Alamo rivers at the Sea's south end.

Undesirable consequences of tilapia becoming established in the Salton Sea prompted an attempt to eradicate them from the pond and tributary with rotenone in January 1964. Over 5,000 dead tilapia (approximately 770 pounds) were removed from the pond, alone. A random sample showed these fish averaged 2.2 ounces each and ranged from 1.2 to 8.5 inches TL. In addition, the pond contained five channel catfish, *Ictalurus punctatus*, 12 to 15 inches long; one, 14-inch largemouth bass, *Micropterus salmoides*; numerous mollies, *P. latipinna* and *P. mexicana*, 0.5 to 2 inches long; and a single 2-inch angelfish, *Petrophyllum cimekei*.

The tributary flows through a dense growth of tamarisk, *Tamarix* sp., salt cedar, *Monathochcoe* sp., bulrushes, *Scirpus* sp., and cattail, *Typha* sp. Complete extermination of the tilapia seemed improbable because of the near impenetrability of the vegetation and the devious nature of the water flow.

During a reinspection of the area on June 2, 1965, Paul Giguere, Walter Thomsen, and I captured a mature male tilapia in the tributary. We also observed numerous adult and juvenile tilapia in a shallow sump at the south end of Sargent's hatchery. There is no surface connection from the sump to the tributary; it apparently receives water through the soil from hatchery ponds. On June 16, 1965, Giguere and I observed several juvenile tilapia in the tributary and captured a mature female. From these observations, we concluded that a breeding population now exists in this small drainage.

REFERENCES

Brock, Vernon E., and Michio Takata. 1954. A note on spawning of *Tilapia mossambica* in sea water. Copeia, 1954 (1):72.

Carpelan, Lars H. 1961. Physical and chemical characteristics. (In) The ecology of the Salton Sea, California, in relation to the sportfishery. Edited by Boyd W. Walker. Calif. Dept. Fish and Game, Fish Bull., (113):1-204.

Hickling, Charles T. 1963. The cultivation of *Tilapia*. Sci. Amer., 205 (5): 143-152.

Lowe (McConnell), R. H. 1955. Species of *Tilapia* in East African dams, with a key for their identification. East African Agric. Jour., 20 (4): 256-262.

—*James A. St. Amant, Inland Fisheries, Region 5, California Department of Fish and Game, July 1965.*

A GREENLAND HALIBUT, *REINHARDTIUS HIPPOGLOSSOIDES* (WALBAUM) RECORDED IN SOUTHERN CALIFORNIA

On February 10, 1965, the trawler *Cecelia* captured a Greenland halibut off Ventura, California. Exact capture locality is not known but the fish was netted on the 15-fathom curve within a radius of 2 miles from lat. 34°12′18″ N., long. 119°22′15″ W.

Seven other Greenland halibut have been recorded from California waters: six from lat. 38°N. to about the Oregon border, and one, 8 kilometers below the Mexican border at about lat. 32°26′N.

The Ventura fish, a female 643 mm SL weighing 2,675 g (after thawing) was the largest of the eight specimens. Its otoliths, cleared for 3 months in glycerine, indicated an age of 10 years. Morphometrics of this fish (Table 1) compared with those of Hubbs and Wilimovsky (1964), fit the limitations of the species.

The specimen was deposited in the collection of the Los Angeles County Museum of Natural History as LACM 6600–1.

LITERATURE CITED

Hubbs, Carl L., and Norman J. Wilimovsky. 1964. Distribution and Synonymy in the Pacific Ocean, and Variations of the Greenland Halibut, *Reinhardtius hippoglossoides* (Walbaum). Jour. Fish Res. Bd. Canada, 21 (5): 1129–1154.

—*Jack W. Schott, Marine Resources Operations, California Department of Fish and Game, September 1965.*

TABLE I

Morphometrics of the Greenland Halibut from Ventura, California

Measurements*		Counts		
Standard length	643 mm	Dorsal fin		93
Total length	737 mm	Anal fin		70
		Pectoral fin		12
Head length	31.7	Ventral fin		6
Snout	8.1	Gillrakers		
Maxillary	13.7	lower		16
Interorbital (bony)	3.3	upper		5
Suborbital (fleshy edge of orbit to maxillary)	0.3	Jaw teeth		
Diameter of orbit edge (fleshy horizontal)	3.3	Eyed side	1st row	2nd row
Longest gillraker	1.2	upper	14	40
Snout to dorsal insertion	11.7	lower	9	0
Snout to anal insertion	39.9	Blind side		
Snout to pectoral insertion	28.5	upper	18	28
Snout to ventral insertion	29.1	lower	14	0
Pectoral length	12.1			
Ventral length	6.4			
Pectoral to dorsal insertion	20.5			
Ventral to dorsal insertion	24.9			
Maximum depth (4th anal ray to 24th dorsal ray, visible origins)	32.7			
Longest dorsal ray	10.0			
Longest anal ray	10.6			
Base of dorsal fin	74.7			
Base of anal fin	51.8			
Caudal peduncle depth	7.5			
Dorsal peduncle length	13.4			
Ventral peduncle length	12.3			

* All measurements are in percent of standard length except total and standard length.

NORTHERN RECORD OF A CALICO SURFPERCH, *AMPHISTICHUS KOELZI*

The calico surfperch was previously known only from California and northern Mexico. Tarp (1952) records the range as being from Santo Tomas, Baja California, to Little Head, Trinidad, California.

During a field trip sponsored by the Institute of Fisheries on July 3, 1965, to the Cape Flattery area in Washington, we captured a specimen which is apparently the first to be caught north of California. It was taken at low tide in 3 feet of water at the south end of Shi Shi Beach, 10 miles south of Cape Flattery. This large individual appeared very weak when captured, and might have strayed north of its normal range.

Measurements, expressed as percent of standard length, and counts are: dorsal, IX, 27; pectoral, 27; lateral line, 66 + 4; gill rakers, 7 + 15; scales from dorsal origin to lateral line, 9; scales from anal origin to lateral line, 20; standard length, 203 mm; head, 30.3; snout, 8.0; maxillary, 10.9; eye, 7.4; caudal peduncle depth, 17.0; dorsal base, 63.5; dorsal sheath, 38.0; anal base, 35.7; pectoral length, 29.3; pelvic length, 27.1. All of these counts and measurements are within the ranges given by Tarp, except for the caudal peduncle depth, length of dorsal base, length of anal base, and standard length. The large size

of the fish might account for distortion of these measurements. This specimen is deposited in the collection of the Institute of Fisheries as BC 65–337.

REFERENCE

Tarp, Fred H. 1952. A revision of the family Embiotocidae (the surfperches). Calif. Dept. Fish and Game, Fish Bull., (88) : 1–99.

—*Alex E. Peden and R. C. Best, Institute of Fisheries, The University of British Columbia, Vancouver, Canada.*

LIVE COLORATION OF A JUVENILE *URASPIS SECUNDA* (POEY) FROM THE EASTERN TROPICAL PACIFIC

No record of the juvenile coloration of live *Uraspis secunda* exists (F. H. Berry, pers. commun.). A single specimen, 109 mm SL, was collected by us 10 miles southwest of Punta Guionos, Costa Rica (lat. 09° 45′N, long. 85°43′W). Upon capture, the fish was placed in a bucket of seawater and 10 minutes later color notes and color photographs were made of the live animal. Its basic body coloration was black. Posterior to the head the body coloration was broken into eight black bars by eight gold spaces (Figure 1). The gold interspaces were expanded at

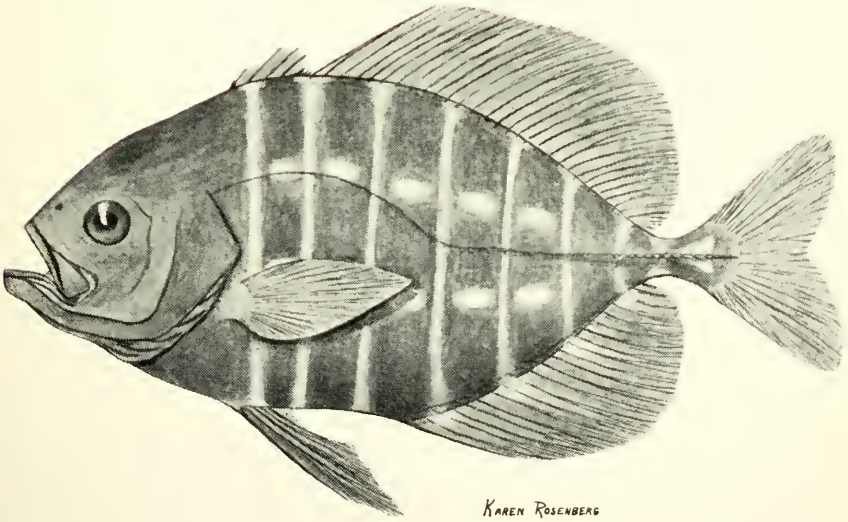


FIGURE 1.—Live coloration of a juvenile *Uraspis secunda*. All shaded areas in the figure were black in the live specimen and the white areas were gold.

their dorsal and ventral ends. The third interspace extended through but not past the scaly sheath covering the base of the second dorsal fin; the dorsal ends of the interspaces 4–7 also extended through only the scaly sheath of the second dorsal fin but their ventral ends extended into the rays of the anal fin. On each of the first five black bars were two

oblong gold spots, one below, the other above or through the lateral line. There was a single triangular gold spot on the caudal peduncle. All fins were black; the axial margin of each pectoral fin was transparent. The inside of the mouth was white.

The fish died shortly after the photographs were taken, about 30 minutes after it was captured. After death, the body color changed rapidly from black to a sooty-yellow. The two rows of spots and the spot on the caudal peduncle became scarcely discernible, and a black nuchal band appeared that extended to the dorsal portion of the eye. Three months later, after preservation in alcohol, the nuchal band was still present but none of the spots was visible.

This fish was among other juvenile fishes captured in a miniature purse seine. The seine was set around a sheet of black vinyl that was suspended on the surface by floats, and was fastened to a mooring for 3 days during experiments on the attraction of fishes to moored objects. Juvenile *Uraspis* may show a habit like many other juvenile carangids of congregating beneath floating materials.

When out of water, *Uraspis* frequently produced sounds similar to the croaks emitted by sciaenids. The croaks were audible at a distance of 3 meters.

This is the first record of this species from inshore areas of the eastern tropical Pacific (F. H. Berry, pers. commun.). The specimen is in the Marine Vertebrates Collection of the Scripps Institution of Oceanography (S10 65-187-42A). Karen Rosenberg prepared the drawing; Frederick H. Berry read the note.

—*John R. Hunter and Charles T. Mitchell, Bureau of Commercial Fisheries Tuna Resources Laboratory, La Jolla, California.*

BOOK REVIEWS

How to Fish the Pacific Coast (Second Edition)

By Ray Cannon; Lane Book Co., Menlo Park, Calif., 1964; xi + 337 p., illustrated, $5.95.

A few forms of ocean fishing along the Pacific coast are not covered in this book, but information and techniques are given for fishing from piers, barges, surf, rocks, and boats, and specialized fishing methods such as using live bait for tuna in southern waters and mooching for salmon in the northwest are explained. The beginner and experienced angler alike will find this a useful guide for proper selection of bait and tackle for the various types of marine sport fisheries to be found along the coast.

Ray Cannon is keenly aware of the importance of sport fisheries, and has been active in promoting and enchancing marine sport fishing for many years. His passion for sport fishing quite often is one-sided, and throughout the book, he downgrades the commercial fishing industry. In many cases, he advocates the exclusion of commercial fisheries where they compete with sport fisheries. His opinion of the commercial fishing industry is summed up in this excerpt from the book: ". . . trying to sustain it [commercial fishing] today is about as sensible as subsidizing blacksmiths . . . market fish are mostly imported and . . . is one of the products which should be imported. Every fish brought in from a foreign country helps save our own resource."

Ray Cannon fails to mention that if the United States does not utilize the fisheries off our coast, other countries may, as is happening in the Pacific northwest.

A major section of the book (unchanged from the first edition) deals with fish identification and contains descriptions and illustrations of nearly every fish the saltwater angler is likely to encounter along the Pacific coast. Unfortunately, many illustrations are misleading, and the descriptions sketchy. The author has attempted to standardize the common names of fish and refers to the names selected by Carl L. Hubbs and W. I. Follett as being the "true common names" used in the book. He then proceeds to use names for rockfish other than those chosen by Hubbs and Follett, or by any other taxonomist. The use of these improper names only serves to confuse still further the nomenclature of these fish.

Ray Cannon's interest in marine biology prompts him to stray from the subject of fishing, in which he is knowledgeable, to the subject of marine biology and ichthyology. However, his statements are not always backed by scientific evidence and his terminology is sometimes very unscientific. He repeatedly refers to findings of fisheries researchers, but the absence of a list of references makes substantiation of these statements difficult.

How to Fish the Pacific Coast (Second Edition), as a guide to saltwater fishing, should find wide acceptance among sport fishermen of the Pacific coast.—*Melvyn W. Odemar.*

Marine Geology of the Gulf of California

Edited by Tj. H. vonAndel and George G. Shor, Jr.; American Association of Petroleum Geologists, Tulsa, Okla., 1964; 408 p., illustrated, $12.50.

Unfortunately, the title of this book scarcely hints of the actual coverage. In addition to "marine geology" there are good sections on the shoreside geology of adjacent areas, on oceanographic aspects of the Gulf, on zoogeography and ecology of macroinvertebrates of the Gulf area, on Gulf ostracods, etc.

More than 20 authors contributed to the 16 chapters which make up this volume. Field work upon which much of this report is based, began in 1958, and most of the observations and samples were collected in 1959 during the *Vermilion Sea Expedition*. Additional trips were made after that to fill in gaps in knowledge and to obtain more refined data in certain areas. Most of the chapters contain a great amount of original information, but previously published works have been utilized and are fully documented.

In addition to an extensive array of text figures, maps, half-tones, etc., 10 plates illustrate more than 150 Gulf mollusks (some for the first time); 3 plates illustrate common living benthonic foraminifera of the Gulf; 1 plate illustrates Gulf ostracods; and 2 plates figure Gulf radiolarians. The mollusk plates are arranged according to typical assemblages by depth—from the intertidal to the bathyal and abyssal.

Organisms illustrated in the other plates also are displayed according to planned systems.

Three large folded charts are integral parts of the volume, but accompany it separately, i.e., they have not been tipped-in, nor is there an attached pocket for them. This is unfortunate, because they are bound to be misplaced, and whether temporarily or permanently, their loss will be felt.—*John E. Fitch.*

Trawlermen's Handbook

Compiled by R. C. Oliver; Fishing News (Books) Ltd., London, 1965; 228 p., illustrated, £1.10.0

This is the 6th edition of the former "Handy Billy" originated in 1906 as a book of rules and regulations for masters of British steam trawlers. Issued by The Hull Steam Trawlers' Mutual Insurance and Protecting Co. Ltd., the current edition has been expanded for use by modern trawlermen and other fishermen.

Throughout its 31 chapters, ample illustrations, definitions, and concise explanations are given on proper navigation and safety at sea.

The navigational chapters incorporate the basic navigational skills required of fishermen. Topics cover the use and application of commonly employed radio and navigational equipment, navigation principles, astronomical and radio navigation, and practical coastal fixing. The effects of tides and tidal streams and basic meteorological observations are also included. Color plates of the International Code of Signals, lights and signals to be shown by vessels, and buoys and wreck-marking vessels provide a ready reference for safe navigation.

The remaining chapters are devoted to safety. Procedures are presented for subjects ranging from knot tieing to rigging and working trawl gear—from life-saving in trawlers to living in a life raft—and from duties of the officer of the watch at sea and in the harbor to fire fighting and meeting emergencies at sea.

Aside from the poor organization of subjects, the *Trawlermen's Handbook* is a very practical and valuable reference for amateur and professional fishermen. The profits gained by others' experiences are excellently portrayed in this book.—*J. Gary Smith.*

The American Oyster Crassostrea virginica Gmelin

By Paul S. Galtsoff, U.S. Govt. Printing Office, Washington, D.C., 1964; 480 p., 400 figs.; $2.75 (paper).

In 18 well-organized and very readable chapters, the author has presented a full discussion of the facts and principles of the biology of the American oyster. For the first time, students of marine biology, professors of invertebrate zoology, the marine biologists, and the oyster industry have a full reference work on the oyster. The research of the author, the studies of other specialists, and strong bibliographies, are presented in each chapter in easy-to-understand style accompanied with fine illustrations.

The volume is not written as a popular "oyster story," but is a treatise of value to both the serious scientist and the inquiring layman. The author is to be congratulated on his full presentation of oyster taxonomy, morphology, physiology, growth, and response to environmental factors. Illustrations of gross anatomy as well as diagrams and photomicrographs support and make complete the presentation of technical details.

Of special significance are the chapters on embryology and larval development which should be studied by all concerned with oyster production. *The American Oyster* is a valuable reference to those studying other species of bivalves and is a must for all scientists, oyster growers, and administrators who have interest in, or responsibilities for oyster resources.—*H. C. Orcutt.*

Stalking the Blue-eyed Scallop

By Euell Gibbons; David McKay Company, Inc., New York, 1964; xiv + 332 pages, illustrated, $5.95.

Most people who visit the seashore are unaware of the variety of seafood that is available to them from the ocean. *Stalking the Blue-eyed Scallop* tells how to take fish, clams, mussels, barnacles, crabs, seaweed, and other resources with simple tools, often the hands. The author describes how to cook this wide variety of seafoods in a manner which would please any palate. The book is accurate and contains line drawing and simple text descriptions that are useful in identifying what you have caught, even if you have had no biological training.

Mr. Gibbons's approach is enthusiastic but conservative, and the manner in which he treats each food item gathered from the sea makes you feel as if that is the ultimate in seafood delights. (I was hungry before finishing the first chapter.) For every fancier of seafood who visits the seashore, and anyone else for that matter, I recommend this book as a delightful and resourceful manual for gathering your own seafood.—*R. Poole.*

Shelling in the Sea of Cortez

By Paul E. Violette; Dale Stewart King, Publ., Tucson, Arizona, 1964; 95 p., illustrated, $1.50 paper, $3 cloth.

The title of this small book is slightly misleading; it implies vast coverage (the entire Gulf of California) when actually it pertains mostly to the Guaymas area. Regardless, the "techniques described here are applicable anywhere." Habits and habitats of many common bivalves, gastropods, echinoderms, and other forms of marine life are mentioned, and most are illustrated with simple, but adequate, sketches.

Extra dividends should have been made available in the sections on sand dollars, sea urchins, and starfishes, but they were not. I could find no mention of the assortment of tiny parasitic snails that are known to infest these creatures, nor was the reader informed of the small commensal crab that lives on the keyhole sand dollar. These omissions can be forgiven, but more serious was the missing conservation message. It wasn't even suggested, that I could find, that the rock-turning shell seeker replace his "divots."—*John E. Fitch.*

The Destruction of California

By Raymond F. Dasmann; The Macmillan Co., New York, 1965; vii + 247 p., illustrated; $5.95.

"Is it more important to get there fast or to have some place worth going to?" This is what the book is concerned with, quality versus quantity. What is progress? Is progress always good? These are the major issues Raymond Dasmann wants each person to ask of himself.

Dr. Dasmann is a very graphic writer and the word pictures he creates of the history, present and future, of California are frightfully clear. He describes the state as it was found by the first explorers. He points out the abundance of game, timber, rangeland, water, pure air, and most important—space. Step by step the reader is brought to the present time. Many areas of past destruction are pointed out, and the scenes are again brought to life before the reader's eyes.

Dasmann has been fair and honest in his writing. He has not put all the blame on any one group such as lumbermen (loggers), dam builders, stockmen, etc., but has put it where it truly belongs, on the shoulders of each citizen living in California.

At times the reader may feel that the author is an old man sitting in his rocking chair and dreaming of the "good old days." Reading farther it is evident that he has analyzed the situation and has placed the facts before the reader. "The critical problem in California today is that of population increase." and ". . . the world crises that compel our attention are related to natural resource and population problems." These are factual statements. What can we do about it? Dasmann answers by saying, "It is perhaps not reasonable to attempt to stop population growth all at once, but it is unreasonable to do nothing about it." Will we one day look back and long for the "good old days" of 1965 when there were only 18 million people in California?

Dr. Dasmann does not expect California citizens to change their direction overnight, but he does want them to slow down and take stock of what is happening around them. He wants them to ask themselves, "Is it more important to get there fast or to have some place worth going to?"—*Dick Laursen.*

Bioluminescence

By H. Arthur Klein; J. B. Lippincott Co., Philadelphia/New York, 1965; 184 p., illustrated, $4.25.

Author Klein's digressions into the logic behind scientific terminology and systematics generally are so painfully presented, that as I read them I couldn't help but wonder who he was trying to convince—himself or his reader. However, if one can ignore or overlook these parts of the book, he will find much of the remaining text as enlightening as bioluminescence itself.

Glowing terminology explains various bioluminescing organisms, and some light is shed on the "trials and tribulations" of investigators who have searched out the secrets of this phenomenon. The photographs used to illustrate the text are lucid in their detail and the numerous sketches are illuminating.

The volume clearly can be a useful addition to one's library.—*John E. Fitch.*

Enjoying Life as a Sportsman's Wife

By Jean C. Vermes; Stackpole Books, Harrisburg, Pa., 1965; 192 p.; $4.95.

Here is a light-hearted little book written by a fellow woman who obviously knows her subject. I read it to see how my experiences as the wife of a professional fishery worker, who also is a life-long angler, compared with hers, and found there really was very little difference, except that author Vermes had prepared a more detailed study of this subject than the average hunter or fisherman's wife. She has done a thorough job of researching her book, and it comes out very neatly as a result. One point that proved this to me was her observation that miniature marshmallows are effective trout bait in San Francisco's Lake Merced. Quotes from Isaak Walton, Byron Dalrymple, and other experts further reveal that Mrs. Vermes knows her subject.

Particularly attractive chapters were the ones on cooking fish and game, and on camping and hunting. The glossary of terms used by hunters was also interesting, but the definition of antlers as being "part of the sexual equipment of the male of the deer family, used to fight other males during the rutting season for possession of the females. Also trophies coveted by sportsmen," was more than a little confusing.

I realize that the cost of illustrating books is probably high, but I missed having an occasional photo or sketch to illustrate what she was writing about. In fact, I couldn't find a single illustration in the book. This economy in publication is further demonstrated by inexpensive paper stock. However, these are minor points.

There are probably other books on the market covering this subject. Possibly some are better, but this is the only one I have read and I enjoyed it thoroughly. I will keep it and refer to it whenever I have a non-technical question about the out-of-doors. I recommend it highly for others who may also have questions on this subject. —*Shirley A. Ryan.*

Biology of the Antarctic Seas II

Edited by George A. Llano; American Geophysical Union, Washington, D.C., 1965; 280 p., illustrated; $12.

This book is the fifth volume in the series released by the American Geophysical Union detailing various types of Antarctic research. This volume contains eight papers, one devoted entirely to physical data, the remaining to various biological phenomena.

An oceanographic study of McMurdo Sound, Antarctica, is the subject of the first paper. The author discusses summer and winter temperature and salinity patterns, photosynthesis, phosphate and silicate concentrations, current systems, light transmission through the ice, and the composition of the substrate.

The next three papers discuss studies of reproductive periodocities of several populations of starfish; primary productivity of phytoplankton in the Weddell Sea; and Weddell Sea microplankton. A study of the sediments both north and south of the Antarctic Polar Front and its Radiolarian components is the subject of the fifth paper. The resulting evidence suggests a cooling of Antarctic waters since late tertiary times, which ultimately resulted in the glaciation of Antarctica.

The sixth paper discusses studies of the midwater fishes of the Peru-Chile Trench. Collections of fishes from midwater depths from about lat. 62° S. to lat. 35° S. led to the discovery of a major faunal break around lat. 20° S. Only 17 percent of the species captured were found both north and south of lat. 20° S., the remaining 83 percent were found only north or south of this latitude. One hundred species representing 31 families were collected during this study, including four which were new to science. The collection also extended the ranges of 79 species.

The last two papers deal with monogenetic trematodes from the southern Pacific Ocean. In the first of these, 5 of 29 observed species of Monopisthocotyleids are described, 3 for the first time. Descriptions of 14 species of Polyopisthocotyleids, 11 for the first time, are given in the second paper. These studies were of particular interest because of the possibility of using these parasites to identify fish races or stocks, or even to differentiate closely allied species of fish.

The series is designed to provide a source of information for scientists interested in the fields concerned, and laymen familiar with the biological and physical sciences. I think this particular volume will be of value to anyone interested in environmental and distribution relationships of marine animals, and in the methods for observing and measuring these phenomena.—*Daniel W. Gotshall.*

Seals of the World

By Judith E. King; The British Museum (Natural History), London 1964; 154 p., illustrated; 11 shillings (paper).

The pinnipeds are perhaps the most easily observed of all marine mammals. Thus they attract thousands of visitors to their accessable rookeries and concentration areas. Most seals have also been the subject of controversy between conservationists and various commercial interests. This book will be of interest to all who enjoy watching and studying seals, as well as a source of facts for those who would exploit or exterminate them.

The author has done an admirable job of bringing together the known life history data on all of the world's pinnipeds. In all, 33 species are described and classified. Such known facts as distribution, size, breeding habits, food, migrations, size of population, enemies, and maximum known age are listed for each species.

After presenting the description and life histories of the individual seals, the author discusses such topics as: ocean currents and seal distribution; external shape and locomotion; and general physiology and anatomy. She discusses one interesting mystery that has yet to be solved: what is the function of the stones found in most of the stomachs that have been examined? It has been theorized that these stones might be used to grind parasitic worms, or as ballast, or even to relieve hunger pangs during fasting. The last two chapters deal with the pinniped fossil record, and a list of parasites. The author has included a section on the origin of scientific names along with her list of references and index.

I found the book extremely interesting and hope that the discussion of the food habits will help dispel some of the myths of reputed damage done by sea lions and seals to commercially valuable fish stocks.—*Daniel W. Gotshall.*

The Lemon Sole

By Bennet B. Rae; Fishing News (Books) Ltd., London, 1965; 106 p., illustrated £1.5.0.

This volume is another in the Buckland lecture series. Dr. Rae has devoted many years of his fisheries research career studying the lemon sole, and here reports on the results and implications of his studies.

He begins with a discussion of the distribution and production of the European fishery with particular emphasis on developments in Scotland. In the following chapters, life-history and biology, including reproduction, larval development, and food and growth of the lemon sole, are described in detail. He has also included the results of tagging experiments showing the migratory habits of this fish in the North Sea in the vicinity of Scotland. Dr Rae's comments on the seasonal abundance of lemon sole and the effects of intensive fishing, and possible reasons for the resistance to overfishing add greatly to understanding the causes for fluctuations in the fishery. In the final section, discussions of parasites, diseases, abnormalities, mutilation, and predators, are presented as additional biological information of the species to complete the lemon sole story.

The direct style of presentation and ample illustrations make this book of interest to fishermen and biologists alike. His discussion of the relationship of growth and food should be of particular interest to anyone concerned with flatfish development. —*J. Gary Smith.*

Museums U.S.A. A History and Guide

By Herbert and Marjorie Katz; Doubleday & Co., Inc., Garden City, New York, 1965; x + 395 p., illustrated; $6.50.

The authors present in one volume a layman's guide to museums of all types in this country (2,500 are listed). With such broad coverage, it is impossible to give any great detail about any one museum. It includes art, science, history, children's, and miscellaneous museums. It traces in a general manner the change from the old style museum (classified by some as "a dead file of moth fodder") to the vitalized modern-day exhibits with their interpretive value.

The descriptions of various museums are quite shallow, with an attempt to emphasize some colorful anecdote rather than to provide a documented history. For

example, the description of the activities of the California Academy of Sciences reads: "The Academy produces Science in Action, a weekly television show from which a dozen alligators once escaped and publishes Pacific Discovery, a popular science magazine."

Over 108 pages of appendix are devoted to a list of all U.S. museums, which in the reviewer's opinion would have been more suitably placed in a periodical catalogue since the information is dated. Enthusiasm for this volume will be largely limited to the layman rather than museum people or scientists.—*Willis A. Evans.*

Meet the Southwest Deserts

By Philip Welles; Dale Stuart King, Publ., Tucson, Arizona, 1964; 84 p., illustrated; $1.50 paper, $3.00 cloth.

Here is one of the nicest little primers available to the visitor who is interested in knowing a little something about the flora and fauna of the American southwest deserts. If there is any doubt about the area under discussion it is dispelled by opening the front cover, where one will find a key map of the western United States and Mexico. Included in the text are descriptions of the desert's more common plants, mammals, birds, reptiles, and insects. Each organism mentioned is illustrated by either a photograph or sketch in typical pose. While not exhaustive, a list of a dozen references may be consulted for additional information on a particular species or area.

For the person who considers the desert a bleak, hot, lifeless area through which he must travel to reach a desired destination, this little book should prove a revelation. The "desert rat" will also find it useful for a greater appreciation of his surroundings.—*William L. Craig.*

Wild Dogs

By C. B. Colby; Duell, Sloan and Pearce, New York, 1965; 128 p., illustrated, $3.95.

As the straightforward title implies this book presents descriptions and natural history notes about the wild relatives of Shakespeare's "Old Dog Tray." The dog family Canidae is a large one and contains not only "man's best friend" but some of his worst enemies. Because the family is so large, Mr. Colby has chosen to describe an interesting member from each of 17 canine types, instead of giving an exhaustive treatise on the entire group. Also included is a chapter about the Tasmanian wolf, not a true canine but a marsupial that is more dog-like in appearance and actions. Of 18 species discussed, 7 are found on the North American Continent.

All the photographs are excellent and together with track illustrations, complement the text beautifully. Although it seems to have been written for a youthful natural history audience, the book is not one bit beneath anyone who is interested in a lot of good information about wild dogs.—*William L. Craig.*

o

printed in CALIFORNIA OFFICE OF STATE PRINTING
57921—800 11-65 5,300

POSTMASTER: If not delivered in 10
days please return to
Editor, CALIFORNIA FISH AND GAME
California State Fisheries Laboratory
TERMINAL ISLAND, CALIFORNIA 90731

RETURN AND FORWARDING POSTAGE GUARANTEED